NATURAL URANIUM SERIES RADIONUCLIDES IN THE UPLAND VEGETATION OF NORTHERN SASKATCHEWAN AND ADJACENT NORTHWEST TERRITORIES

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EXECUTIVE SUMMARY

General public concerns about radiation exposure and specific concerns about the potential impacts of uranium mining and milling have created a need for extensive, credible data on natural baseline radiation levels in the environment.

There is a lack of such data in Canada, particularly with respect to radionuclide levels in northern regions. The ecosystems of these regions, because of their nature, may channel seemingly low levels of radionuclides into measurable concentrations in higher biota, including humans.

An important source of natural radiation is the decay series of uranium-238 (U^{238}, half-life $4.5x10^{9}$ years), the products of which include radium-226 (Ra^{226}, half-life 1622 years), the gas radon-222 (Rn^{222}, half-life 3.8 days), lead-210 (Pb^{210}, half-life 22 years) and polonium-210 (Po^{210}, half-life 138 days). The order of radiotoxicity for the series is $Pb^{210} > Ra^{226} > Po^{210}$ (ICRP 1979). Since Pb^{210} and Po^{210} are the disintegration products of radon gas they are distributed in the atmosphere and return to earth primarily adsorbed onto dust particles. Uranium and Ra^{226}, in contrast, are not reported to be naturally distributed in the atmosphere in important amounts.

The purpose of this study was to obtain extensive data on baseline concentrations of uranium series radionuclides in the vegetation of northern Saskatchewan and adjacent Northwest Territories. These data were assessed for overall levels and the variability in levels among three study regions, among localities within the study regions and among plant species.

Three primary objectives of the project were to:

- determine if differences in baseline radionuclide concentrations in upland (convex landforms) vegetation occur among three regions in northern Saskatchewan and adjacent N.W.T., or among localities within these regions;
- determine if differences in baseline radionuclide concentrations occur among species groups, (lichens, shrubs and trees) or between species within these groups;
- determine if radionuclide concentrations in plants correlate with those of stable elements.

Other objectives were to:

- identify plant species and groups which are heavy accumulators of radionuclides and which have the potential to transfer radionuclides along food chains to man;
- investigate the possible effects of forest fires on radionuclide accumulation by upland plants;
- assess the value of lichens in monitoring atmospheric sources of radionuclides due to human activities.

Three radionuclides were selected for the vegetation study based on their environmental mobility, radiotoxicity and chemical toxicity. The selected radionuclides were Ra^{226}, Pb^{210} and uranium. A preliminary study had shown Po^{210} to behave in plants in an analogous manner to Pb^{210}. Lead-210 and Ra^{226} are bone seekers; therefore, their highest levels in animals occur in bone and their transfer to man through game animals is partially blocked because human consumption of bone, other than by boiling, is not usual. Polonium-210 is potentially a more serious hazard to man since it accumulates in flesh. However, Po^{210} has a relatively low radiotoxicity because of its high biological

turnover rate. The chemical toxicity of uranium is probably of more concern than its radiotoxicity due to its very low radioactivity (extremely long half-life).

Few significant differences were found among regions (Wollaston Lake, Cluff Lake, and northernmost Saskatchewan and adjacent N.W.T.) based on the radionuclide concentration of individual plant species. However, when the concentrations of all elements in the most commonly sampled species were analyzed simultaneously, significant differences between the three regions were detected. The radionuclides Ra^{226} and uranium were among the elements responsible for these differences. Radium-226 had a high average concentration for the northernmost region and uranium a high value for the Wollaston Lake region.

There was more variation in average element concentration among plant species than among localities and significant differences were detected among most of the commonly sampled species. Lichens (non-rooted plants) were statistically separable from vascular plants (shrubs and trees) by high concentrations of Pb^{210} and three crustal elements (lead, iron and titanium) all of which occur in the atmosphere as dust.

High concentrations of Pb^{210} in lichens are derived from the decay of radon gas in the atmosphere and the subsequent deposition of solid decay products on the plants. Lichens lack roots and therefore rely on atmospheric deposition for their nutrients, whereas the roots of vascular plants take up their nutrients and other elements, including radionuclides, from the soil.

Among the vascular plants, shrubs accumulate particularly high concentrations of Ra^{226} from the soil. Lichens naturally accumulate

only small quantities of Ra^{226} since this radionuclide is not naturally present in the atmosphere in important quantities.

High natural concentrations of uranium were also detected in lichens during the present study. This was not expected because uranium has not previously been considered to be naturally transported in the atmosphere. However, literature reports indicate that other heavy metals are excreted into the wax layer of conifer needles and preliminary evidence suggests that this is also the case for uranium. This apparent method of cycling of uranium and other heavy metals in the environment requires further study.

Maximum radionuclide concentrations recorded in various species were often either the highest or among the highest previously reported. Concentrations of Pb^{210} and Ra^{226} in the trees and shrubs exceed previous reports. In contrast, uranium concentrations in trees and shrubs are lower than some levels previously reported. Uranium concentrations in lichens are mostly higher than previously reported.

No high correlations between specific stable elements and radionuclides were detected. There was one general correlation, between Pb^{210} and certain crust derived elements (distributed in dust) that are deposited on lichens from the atmosphere.

There are literature reports that the lichen → caribou → man food chain results in higher concentrations of Pb^{210} and Po^{210} in northern residents with high caribou consumption than in southern residents. Because of their abundance in the north and their ability to trap atmospherically distributed elements, the caribou lichens (Cladina species) are the most important plant species in this food chain. The present study suggests that uranium, and other heavy metals such as

lead, may also enter the lichen food chain in more heavily forested areas.

Other food chains involving moose, spruce grouse and berries may also result in natural radionuclide transfer to man. High shrubs are important winter browse for moose and have been found to have high concentration of Ra^{226}, intermediate levels of uranium and low levels of Pb^{210}. Spruce grouse feed primarily on spruce needles (Picea mariana) and in some localities may be subject to a high transfer of uranium. Because of technical problems with sample preparation, the radionuclide content of berries could not be included. Berries could be involved in direct transfer to man from study shrubs such as Canada blueberry (Vaccinium myrtilloides) and cranberry (V. vitis-idaea).

Given the importance of caribou and moose (and to some extent grouse and berries) to northerners and our environment, radionuclide transfer through these food items from plants to man requires consideration for further study. Any future such studies should also consider the radionuclide Po^{210}.

The potential effect of forest fires on radionuclide accumulation in vegetation was investigated by sampling adjacent burned and unburned sites at five localities in the Cluff Lake region. No consistent effect could be detected in either of the two plant species studied or the soil.

Lichens are appropriate plants for monitoring atmospherically distributed radionuclides, but may also be useful for monitoring uranium, and Ra^{226} which are not widely distributed in the atmosphere. To support the conclusion, we found elevated concentrations of all three study radionuclides at the Mill Site locality, Cluff Lake region, probably due to adjacent mining and milling activity. The average

levels of Pb^{210} and Ra^{226} in the vegetation at the Mill Site were not, however, as large as natural levels at one other study locality.

TECHNICAL SUMMARY

To accomplish the objectives outlined in the Executive Summary, three radionuclides in the uranium series were selected for study in the upland vegetation of northern Saskatchewan and adjacent Northwest Territories based on their environmental mobility, radiotoxicity and chemical toxicity. These were radium-226 (Ra^{226}), lead-210 (Pb^{210}) and uranium. A preliminary study had shown polonium-210 (Po^{210}) to accumulate in plants in an analogous manner to Pb^{210}. Lichens are consumed by caribou and hence are at the base of an important food chain to man in the northern part of the area studied. Because Pb^{210} is a bone seeker its transfer to man is partially blocked. Radium-226 is less radiotoxic than Pb^{210} and also accumulates in bone. The greatest potential hazard to man from this food chain is Po^{210}, which accumulates in flesh but has a lower radiotoxicity than either Pb^{210} or Ra^{226}. Polonium-210 is known to have elevated concentrations in caribou-eating residents of the north. The potential for transfer of uranium to man by this food chain is not known but the chemical toxicity of uranium is probably of more concern than its radiotoxicity.

Three regions were sampled: Wollaston Lake, Cluff Lake, and northernmost Saskatchewan and adjacent N.W.T. A total of twenty localities within these regions were sampled on the basis of a broad selection of plant species available in sufficient quantity for collection. A total of eighteen species representing the plant groups lichens, shrubs and trees were collected. Only one species, cranberry (Vaccinium vitis-idaea), was found at all localities. Only the living tissues of the lichens were sampled. For the high shrubs and deciduous trees the young shoots were sampled and the leaves removed. The whole

shoots, including their leaves, of the ground layer shrubs and the needles of the conifers were sampled unless otherwise specified.

The choice of tissues sampled was based on those most commonly used by animals in food chains leading to man. Caribou graze only the upper portions of lichens and hence care was taken not to sample the lower, dead portions of these plants. Moose browse on twigs of deciduous trees and tall shrubs in winter, therefore, the leaves of paper birch (Betula neoalaskana), trembling aspen (Populus tremuloides) and green alder (Alnus crispa) were stripped from the stem after collection. The needles of the conifers, black spruce (Picea mariana) and jackpine (Pinus banksiana), were removed for analysis because the needles of spruce are consumed by spruce grouse.

All of the sample regions contain past or present uranium mines and significant uranium mineralization. However, only three localities within these regions are closer than 5 km to past or present uranium mines. The Mill Site locality in the Cluff Lake region is 500 m from the active mill and tailings area of Amok/Cluff Mining. The Eagle Lake and Uranium City localities within the northernmost Saskatchewan and N.W.T. region are within 2 km of past uranium mining activity. These latter two localities have uranium mineralization on-site.

Four other localities (Midwest Lake, Parks Lake, Hidden Bay and McInnes Lake) are within general areas of significant uranium mineralization. However, only the McInnes Lake locality has mineralization on-site. The other three are more than 5 km from recorded showings. The Tazin River locality is about 3 km from a minor surface showing. No other localities are near recorded mineralization.

The three radionuclides have their highest concentrations in different regions. The Wollaston Lake region has slightly higher

overall Pb^{210} levels. Northernmost Sask./NWT has the highest overall Ra^{226} levels. The Cluff Lake region has the highest overall uranium levels, however, when the high average Cluff Lake uranium levels at the Mill Site locality are removed, the Wollaston region has higher uranium levels.

The three regions are significantly different in their pattern of accumulation of stable elements and radionuclides by vegetation. The Cluff Lake region (excluding the Mill Site), with no significant differences between localities within it, is the most homogenous and the Wollaston Lake region is the most heterogenous. Among regions, Wollaston and Cluff Lake are the most similar and the Cluff Lake and the northernmost Sask./N.W.T. regions have the most differences between their localities.

The highest levels for the three radionuclides in the Wollaston Lake region are at Collins Creek for Pb^{210}, Parks Lake for Ra^{226} and Collins Creek for uranium. These results do not consistently relate to known uranium mineralization. The highest levels of all three radionuclides in the Cluff Lake region are at the Mill Site. This can be directly related to the uranium milling activity nearby. The Eagle Lake locality has the highest levels for all three radionuclides in the northernmost region. This is shown to be due to uranium mineralization at the site.

The study illustrates the difficulty in generalizing about radionuclide concentrations in vegetation at different locations because the species present vary from place to place. Nevertheless there are several significant species differences in radionuclide concentrations among localities within regions and the species account for one order of magnitude more variance than do the locality differences. Among the

three plant groups, lichens have the highest Pb^{210} and uranium levels and shrubs have the highest Ra^{226} levels.

Multivariate statistical analyses revealed that the vascular plants were significantly different from the non-vascular plants (lichens and mosses) in their pattern of element uptake. The vascular species were characterized by seven essential elements (Mg, B, Ca, P, Cu, Mn and K). The non-vascular species were characterized by Pb^{210}, uranium and a set of crust-derived elements (Ti, Fe, Pb, Be and Al) distributed in the atmosphere. The association of uranium with atmospherically distributed stable elements was unexpected since it was previously thought to be taken up by the roots of vascular plants only. The uranium in non-vascular plants is now hypothesized to be derived from wax particles shed from the surface of conifer needles and locally transported in the atmosphere. Radium-226 did not show affinity to either plant group. The pattern of distribution of Ra^{226} showed more similarity to that of barium than to that of calcium, with which it is often compared.

When the vascular and non-vascular plants were analyzed separately, additional general correlations were not revealed. However, some interesting and more specific patterns were detected. Canada blueberry (Vaccinium myrtilloides) at Cluff Lake is a major source of variance among the vascular plants due to high concentrations of some essential and passively (non-selectively) cycled elements (V, B, Ag, Ti, Cr, Fe and Mn). Green alder (Alnus crispa) has a high concentration of cobalt, an essential element for its nitrogen fixing system. The moss samples were shown to have relatively high concentrations of nutrient elements and in this respect show more similarity to the vascular species than to the lichens.

The four most northerly localities have the lowest concentration of crustal elements detected among the non-vascular plant samples. This may indicate the influence of air masses originating over the Arctic Ocean rather than over land.

Most species, with the exception of some lichens and shrubs, were shown to differ significantly in their uptake pattern of stable elements and radionuclides.

There was no good correlation between the vegetation or soil concentrations of any of the three radionuclides and the stable elements that would be of predictive value to those interested in pollution or waste disposal monitoring.

There were important differences among species within the plant groups. Among the tree species, paper birch (Betula neoalaskana) has the highest concentration of Pb^{210} and Ra^{226}, and jackpine (Pinus banksiana) the highest natural uranium content. Among the shrubs, Canada blueberry (Vaccinium myrtilloides) has the highest concentration of Pb^{210} and uranium, and Labrador tea (Ledum groenlandicum) the greatest accumulation of Ra^{226}. The caribou lichens accumulate Pb^{210} and uranium in the order Cladina stellaris > C. mitis > C. rangiferina, primarily from the atmosphere. Radium-226 concentrations in lichens are uniformly low because it is not naturally distributed in the atmosphere.

Radium-226 and Pb^{210} levels recorded in this study are among the highest detected in natural environments. Maximum concentrations of Pb^{210} in conifers marginally exceed levels recorded in a region of high radioactivity in British Columbia. Concentrations of Pb^{210} in deciduous trees and shrubs exceed levels recorded elsewhere by approximately one order of magnitude. However, higher levels of Pb^{210} have been recorded in lichens from Alaskan tundra. Maximum concentrations of Ra^{226} in

trees and shrubs also exceed literature reports and those for lichens are comparable. In contrast to Pb^{210} and Ra^{226}, uranium concentrations in trees and shrubs are lower than some levels reported in the literature. However, uranium concentrations in lichens in this study are mostly higher than literature reports.

Further study of the lichen-caribou food chain would seem desirable. Attention should focus on the accumulation of Pb^{210} and Ra^{226} in caribou bones, and on the levels of Po^{210} and uranium in the muscle and internal organs (liver and kidney) of the caribou.

Shrubs are an important food for moose throughout the year but browsing on high shrubs in winter is particularly important. High Ra^{226} concentrations in shrubs suggests that this radionuclide could be important for moose and within the moose food chain. Studies of the plant-moose food chain in northern Saskatchewan should be considered.

The potential effect of forest fires on radionuclide accumulation in vegetation was investigated by sampling burned and unburned sites at five localities in the Cluff Lake region. No consistent effect could be detected in either of the two species studied (jackpine, Pinus banksiana and blueberry, Vaccinium myrtilloides) or in the soil.

It is known that plant exudates can be an important source of Pb^{210} and other heavy metals in the atmosphere. Preliminary studies have shown that fifty percent of the uranium in jackpine (Pinus banksiana) needles resides in the surface wax layer. This wax is continuously shed, depositing uranium on ground lichens, thereby cycling uranium back to the soil or to any caribou grazing on the lichens. Since this uranium is shed in particles it is probable that its distribution in the atmosphere is more localized than radon-derived Pb^{210} and Po^{210} and limited to regions where there is high uptake of uranium by conifers

from the soil. The cycling of radionuclides and chemotoxic elements through vegetation is a topic worthy of further investigation. This study thus presents evidence that the factors involved in the terrestrial cycling and accumulation of uranium and Ra^{226} are different.

Lichens have been used to study the fallout of elements naturally distributed in the atmosphere and to monitor atmospheric pollution levels including radionuclide fallout from various airborne nuclear releases. As in this study, they have also been used to assess the levels of some naturally occurring radionuclides in the environment. These data will help distinguish between natural and anthropogenic sources. The present study indicates that lichens are appropriate plants to monitor enhanced concentrations of uranium in the terrestrial environment due to uranium mining and milling activities. Because Ra^{226} is not naturally distributed in the atmosphere in important amounts, lichens are also particularly well suited to monitoring this radionuclide in the vicinity of uranium mining operations. In attempting to determine if enhanced levels of uranium, Ra^{226} and Pb^{210} in vegetation are associated with uranium mining, it is useful to obtain associated data on radionuclide levels in the soil and data on ash weights for the vegetation. These data will help to distinguish between natural and anthropogenic sources.

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1. INTRODUCTION

1.1 Rationale

"The strangest paradox of radiation protection is that the least attention is paid to the strongest sources of human exposure.... It is no exaggeration to say that public and professional interest in natural and artificial radiation is inversely proportional to the radiation dose received from them" (O'Riordan 1983). A very important and, to date, inadequately studied source of exposure is foodchain transfer of naturally occurring radionuclides (Figure 1). In Canada, there is a growing awareness of the need for research on background radiation in the biotic environment (Shemilt 1983).

An important source of natural radiation is the decay series of uranium-238 (U^{238}, half-life 4.5×10^9 years), the products of which include radium-226 (Ra^{226}, half-life 1622 years), the gas radon-222 (Rn^{222}, half-life 3.8 days), lead-210 (Pb^{210}, half-life 22 years) and polonium-210 (Po^{210}, half-life 138 days). The Ra^{226} - Po^{210} chain is an important source of man's background radiation burden (Blanchard 1967) and the order of radiotoxicity for the series is $Pb^{210} > Ra^{226} > Po^{210}$ (ICRP 1979). Since Pb^{210} and Po^{210} are the disintegration products of radon gas, they are distributed in the atmosphere and return to earth primarily in fallout processes. Experimental work with crop plants has shown that the main source of Pb^{210} is from atmospheric fallout. Forage crops, with their high surface area relative to vegetables and grain, have the highest air-plant transfer coefficients (Francis et al. 1968, McDowell-Boyer et al. 1979) for radionuclides. Uranium and radium^{226}, in contrast, would be expected to be taken up from the soil (Cannon 1952, Sheppard 1980a,b), and uranium is sometimes accumulated in plants in impressive amounts (Dunn 1983a). Uranium may also be distributed as

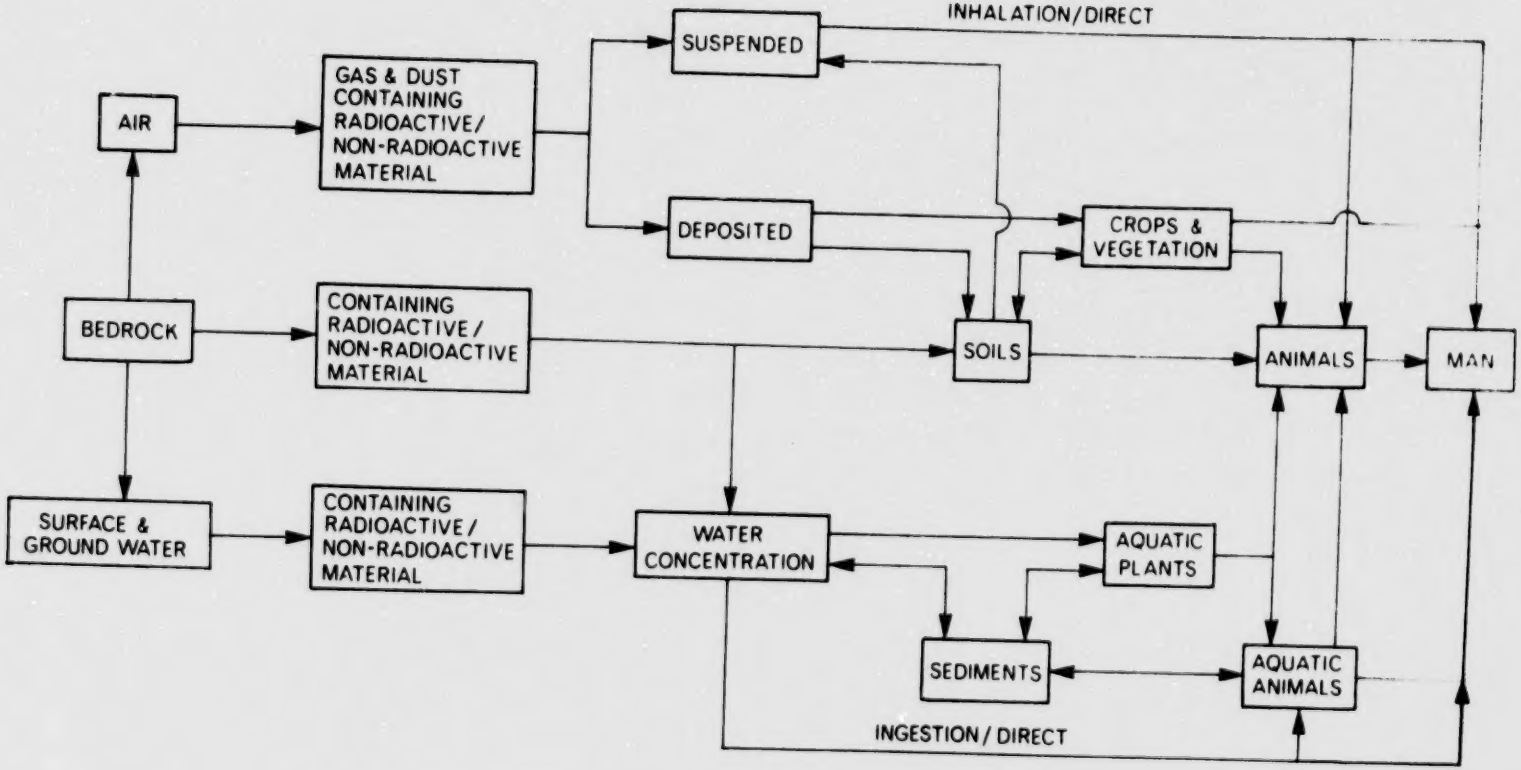


Figure 1. Flow chart for exposure and accumulation pathways of natural radionuclides in biota.

particulates and has been accumulated by lichens up to 22 km downwind of Elliot Lake (Beckett et al. 1982). Cloutier et al. (1983) report a high concentration of Ra^{226} in plants growing on mine tailings at Elliot Lake, Ontario.

The upland vegetation (that on convex landforms) of northern Saskatchewan consists of conifer forests which, if they remain undisturbed by fire, may develop into open lichen woodlands (Black and Bliss 1980, Carroll and Bliss 1982, Rowe 1984). The tree species black spruce (Picea mariana) and jackpine (Pinus banksiana), together with the vascular plants of the shrub layer, are expected to take up uranium and Ra^{226} through their root systems. The lichens and mosses, which lack roots and internal transport mechanisms, are expected to accumulate relatively large amounts of Pb^{210} and Po^{210} from the atmosphere (Boileau et al. 1982, Folkeson 1979). This effect may be further enhanced by the lack of a cortex (outer protective layer) and consequent extremely rough surface in the caribou lichens of the genus Cladina, which in mature forest stands form the predominant ground cover.

There is no extensive regional information on baseline radionuclide concentrations and hence on the natural variation of radionuclide levels in the terrestrial environment. Because of this lack, it is very difficult to interpret baseline or monitoring data from uranium mines, or biogeochemical data. For example, the magnitude and extent of variation in radionuclide levels among regions and species has to be known before the significance of lichen radionuclide levels near ore-haul roads can be assessed. A "higher than usual" uranium level in trees, as found during a biogeochemical survey, may or may not indicate nearby mineralization, depending upon how uranium is distributed among

and between plant groups, and on the role that plants take in uranium cycling.

Some information on the accumulation of uranium in natural terrestrial ecosystems is available in the biogeochemical exploration literature (Brooks 1983, Cannon 1952); however, there is less known about the occurrence of radioisotopes of the uranium series in vegetation. Dunn (1983a, b), Mahon and Mathewes (1983) and Walker (1979) have studied uranium accumulation in terrestrial plants over high-grade orebodies. Uranium accumulation over low-grade orebodies and other anomalies has been studied by Dunn (1983a), DiLabio and Rencz (1980) and Sheppard and Thibault (1984). Hill (1966), Holtzman (1966), Kauranen and Miettinen (1969) and Mahon and Mathewes (1983) are important sources of information on Pb^{210}, Po^{210} and Ra^{226} in natural vegetation.

In addition to being of value for environmental monitoring and uranium exploration, a regional study of radionuclides in a variety of plant species will also provide information regarding potential transfer to man via food chains. Northern Saskatchewan has the distinction of being an area where many people remain dependent on wildlife resources for much of their physical and economic well being (Knoll 1980).

There is little doubt that caribou are the most important source of wild meat to the inhabitants of northern Saskatchewan and the adjacent N.W.T. (Muller-Wille 1974). Lichens are at the base of this food chain and were found to have higher levels of Pb^{210}, uranium and Po^{210} than trees and shrubs in a previous study (Sheard 1985). There is a large volume of literature on the accumulation of Pb^{210} and Po^{210} in the lichen → caribou → man food chain (Hill 1966, Kauranen and Miettenen 1969, Holtzman 1966, Blanchard and Moore 1970, Persson 1972).

Concentrations of Po^{210} in individual humans with a high consumption of caribou/reindeer meat are up to 80 times (on average 35 times) levels in individuals with southern diets (Hill 1966). Preferential consumption of liver and kidney could lead to higher individual levels. Lead-210 concentrations are up to 2.5 times southern levels. The lower transfer of Pb^{210} to humans is due to its accumulation in caribou/reindeer bone, creating a partial block in the food chain for this radionuclide.

Other animal species utilized by man are moose, spruce grouse and bear (DTRR, 1980a, 1980b). Shrubs are a food for moose throughout the year, but browsing on high shrubs in winter is particularly important (Stewart et al. 1977). The food chain spruce needle → spruce grouse → man might also be of particular interest in local areas of high radionuclide concentration as grouse are territorial, and individuals have much more restricted ranges than large mammals. A seasonal entry of radionuclides into the berry food chain might also occur in the fall, through bears and more directly by man eating the fruit of blueberry (Vaccinium sp.) and other species.

Northern food chains concentrate unusually high quantities of radionuclides and provide an important vector to humans because: 1) the high surface area of lichens allows efficient adsorption of air-borne radionuclides; 2) the longevity of lichens leads to progressive accumulation; 3) the conservation of elements by lichens and other plants due to poor nutrient conditions leads to retention of radionuclides; and, 4) the channelling of materials into a small array of species and a relatively small biomass results in high levels even when original source levels are very low (Whicker and Schultz 1982).

Phenomena which might cause radionuclide concentrations in plants and animals to move above naturally high baseline levels are therefore a

potential source of concern. At least three such phenomena occur in northern Saskatchewan. These are 1) abandoned, decommissioned and operating orebodies, 2) natural "hotspots" indicative of other orebodies and 3) concentration processes due to the frequent and natural occurrence of forest fires.

It must be emphasized that there is currently no evidence that the populace of northern Saskatchewan is at risk, nor that there is any other evident environmental impact due to enhanced radiation levels. Nevertheless, segments of the population fear radiation damage. The risks from exposure to radiation and the impact of mining activities on these risks can only be assessed from a knowledge of baseline radiation levels.

The influence of forest fires in mobilizing radionuclides has not as yet been extensively investigated. Forest fires have been suggested as a cause for Ra^{226} in the stratosphere (Jaworowski and Knownalka 1976). Carroll and Bliss (1982) have shown that some jackpine-lichen woodlands in a study area south of Lake Athabasca have a natural mean fire return interval of approximately 40 years. Such a fire return frequency ensures that woodland (resident) caribou and other animals could encounter post-fire successional plant communities for significant portions of their life-histories.

There is current interest in the origins of uranium series radionuclides in the atmosphere. It has sometimes been assumed that Pb^{210} in the atmosphere is the sole result of Rn^{222} decay in that environment. However, Rn^{222}/Pb^{210} and Pb^{210}/Po^{210} activity ratios indicate that these radionuclides are not in equilibrium in the atmosphere and additional sources are implicated (Moore et al. 1976). These authors have shown that soil particles and plant exudates are also

important sources of Pb^{210} and Po^{210} in the atmosphere, demonstrating that approximately half the Pb^{210} content of pine needles resides in the waxy outer coating. Beauford et al. (1975, 1977) have shown experimentally that pine seedlings take up lead and zinc from soil solution and release them into the atmosphere.

Lichens provide an integrating method of measuring the fallout of both stable elements and radionuclides from the atmosphere. Thus lichens have been used to determine stable element distributions in the atmosphere over northern Canada (Puckett and Finegan 1980), to study radionuclide fallout as a result of atmospheric nuclear tests (Hanson 1982) and to monitor uranium mining and milling activity in northern Ontario (Beckett et al. 1982). Although lichens are widely recognized as valuable monitors of industrial activity (Nieboer and Richardson 1981), their potential as monitors of uranium mining and milling activity in northern Saskatchewan has never been assessed.

In summary, the rationale for the present study lies in a fundamental need to determine baseline data for the concentrations of key radionuclides in northern vegetation. As has been indicated above, such data are essential to the improved use of plants in exploring for uranium, monitoring and surveillance of the natural environment in the vicinity of uranium mines, and studying the levels and effects of radionuclides in northern wildlife. The present study is concerned solely with vegetation, but has been designed to provide a starting point for possible future studies of terrestrial food chains leading to man.

1.2 Objectives

The overall objective of the study was to obtain extensive data on baseline concentrations of uranium series radionuclides in the upland vegetation of northern Saskatchewan and the adjacent Northwest Territories, and to assess these data to determine the major sources of variation among and within regions, and among and within species groups.

The three primary objectives of the project were to:

- determine if differences in baseline radionuclide concentrations in upland vegetation occur among three regions in northern Saskatchewan and adjacent N.W.T., or among localities within these regions;
- determine if differences in baseline radionuclide concentrations occur among species groups, or between species within these groups;
- determine if radionuclide concentrations in plants correlate with those of stable elements;

Other objectives were to:

- identify plant species and groups which are heavy accumulators of radionuclides and which have the potential to transfer radionuclides along food chains to man;
- investigate the effects of forest fires on radionuclide accumulation by upland plants;
- assess the value of lichens in monitoring atmospheric sources of radionuclides due to anthropogenic activities.

1.3 Study Design Criteria

The first three objectives may be re-expressed as the null hypothesis that radionuclides and stable elements are randomly distributed in upland vegetation with respect to both geographical location and plant species. A rigorous statistical test of this

hypothesis implies a balanced two-way study design. This is known, from a preliminary study, to be unattainable since all species cannot be expected to be present at all sample locations (Sheard 1985, 1986a,b).

Species chosen for sampling were those that were most likely to have a wide distribution in the study area. When they were not available in a given locality other species were collected. This increased the number of species surveyed although not all were extensively sampled. Species to be sampled included tree, shrub and lichen species. Mosses were excluded since they proved to be difficult and time consuming to collect (Sheard 1985) and because they were not identified as belonging to any food chain leading to humans. However, mosses are referred to since data from two localities of the preliminary study (Sheard 1985) are included in the analysis of the present study. Species included in this study are listed with their common names in Table 2 (page 29).

Statistical analyses theoretically require random sampling but this is rarely possible in ecological work because of financial, time and other constraints (Green 1979). The best that can usually be achieved is to reduce sampling bias. It was decided in the present study to sample from three bases that were relatively accessible:- Wollaston Lake and Cluff Lake by road, and Uranium City by air. However, these coincide with active or past uranium workings and since the study is of natural, background levels there is clearly a built-in sampling bias. This was reduced by choosing sampling localities no closer than an arbitrary 5 km from uranium workings and mostly accessed by air charter. Exceptions were single localities near Cluff Lake and Uranium City which were sampled to determine if anthropogenic effects were readily detectable.

The choice of radionuclides was based on environmental mobility, radiotoxicity and chemical toxicity. Uranium, Ra^{226} and Pb^{210} were selected for study. Uranium is relatively mobile in the soil, has a low radiotoxicity but is a potentially significant chemical toxin. Radium-226 has less soil mobility but has a higher radiotoxicity than uranium. Lead-210 is a decay product of radon gas (Rn^{222}) and is therefore distributed in the atmosphere as well as the soil. Lead-210 is a bone seeker, like Ra^{226}, with a high radiotoxicity (ICRP 1979). Analyses for Po^{210}, another product from the decay of radon, were not undertaken, because Po^{210} was shown to have a very similar distribution in plants to Pb^{210} in a preliminary study (Sheard 1985).

The choice of tissues sampled (leaves, needles, or twigs) was based on which tissues were most commonly used by animals in food chains leading to man.

The choice of sample treatment was based on common methods used by other researchers, logistics and the ultimate uses of the results of this study. Thus, for example, washing the plant samples was not done because it is not effective on lichens, because removal of dust would render comparison with monitoring programs impossible and because unwashed plants represent what is eaten by animals in food chains leading to man.

2. MATERIALS AND METHODS

2.1 Study Area

The area of study was northern Saskatchewan and the adjacent Northwest Territories. Within this area three regions were sampled; the Wollaston Lake, Cluff Lake, and northernmost Saskatchewan and N.W.T. regions (Figure 2, see end of the Study Area section). The three regions were chosen for their relative ease of access by road or air. However, they are also the sites of past or active uranium mines and mills. Since the objective was to assess natural background levels of radionuclides, considerable use was made of air charter out of Wollaston Lake, Carswell Lake and Uranium City to reach localities remote from the mine sites. The choice of localities within each region was determined by the presence of a broad selection of species (trees, shrubs and lichens) in sufficient quantity for collection. In addition it was required that the vegetation be homogenous enough to allow three replicate collection sites to be sampled for which there were no visual differences in community structure. Replicate sites were 200 m apart. Two localities sampled in a preliminary study (Sheard 1985) are not included in the following list: numbers 3 and 4, Birch Hill and Otter Rapids respectively, in the more southerly Churchill River region. Twenty localities are included in this study.

Wollaston Lake Region (Figure 3): Northern Boreal Ecoregion (Table 1)

1. Hidden Bay, 58° 07'N 103° 46'E, 24-25/8/83. North of access road to Wollaston Lake Lodge. Athabasca South Ecodistrict, lichen woodland on north side of esker. Collection sites 500 m from road. This and the following locality were part of the preliminary study (Sheard 1985).

2. Collins Creek, 58° 11'N 103° 50'W. 26-27/8/83. South of road to Midwest Lake, adjacent to east shore Kewen Lake. Athabasca South Ecodistrict, open spruce woodland over glacial till. Collection sites 500 m from road.

5. Hungry Island, 58° 07'N 103° 25'W, 14/8/84. Athabasca South Ecodistrict, rock outcrops and glacial till with spruce and paper birch.

6. Cunning Bay, 58° 25'N 103° 35'W, 15/8/84. Athabasca South Ecodistrict, island in bay formed from an esker. Sample sites in mixed spruce and paper birch on lower slopes of esker.

7. Parks Lake, 58° 10'N 103° 30'W, 16/8/84. Athabasca South Ecodistrict, relatively closed spruce forest with some paper birch on morainal plain.

8. Labach Lake, 58° 08'N 102° 50'W, 17/8/84. Northern Coniferous Ecodistrict, open spruce-lichen woodland with some jackpine on sandy morainal plain.

9. Midwest Lake, 58° 16'N 104° 01'W, 18/8/84. Northern Coniferous Ecodistrict, open spruce-lichen woodland over glacial till, 500 m north of end of Midwest road.

10. Minor Bay, 57° 51'N 103°50'W, 19/8/84. Northern Coniferous Ecodistrict, moist spruce woodland with Sphagnum hummocks over lacustrine clay, 500 m from road.

Cluff Lake Region (Figure 4): Northern Boreal Ecoregion, Athabasca South Ecodistrict (Table 1).

11. Carswell Lake, 58° 35'N 109° 33'N, 2/9/84. Open spruce-pine forest on sandy glaciofluvial plain, 1 km from road.

12. South Gate, 58° 10'N 109° 29'W, 3/9/84. Relatively closed jackpine forest on till, 500 m from road. Burn locality (1980),

very open jackpine woodland on sandy glaciofluvial plain, 1 km from road.

13. Carswell Lake north, 58° 40'N 109° 07'W, 4/9/84. Spruce-jackpine woodland on sandy esker. Burn locality (1972) on adjacent esker with boulders.

14. Jolley Lake, 58° 17'N 109° 09'W, 5/9/84. Mature spruce-jackpine woodland on sandy esker. Burn seven years old.

15. Sandy Lake, 58° 18'N 109° 45'W, 6/9/84. Very mature, open jackpine-lichen woodland on sandy glaciofluvial plain. Burn four years old.

16. Mill Site, 58° 21'N 109° 35'W, 7/9/84. Mature jackpine stand on glacial till, 500 m from mill and tailings. Ground burn only (1980).

Northernmost Saskatchewan and N.W.T. Region (Figures 2 and 5).

17. Uranium City, 59° 30'N 108° 40'W, 14-15/8/85. Northern Boreal Ecoregion, Northern Coniferous Ecodistrict. Rocky ridge with well spaced jackpine and spruce, 500 m from road. Evidence of mineral exploration by trenching.

18. McInnes Lake, N.W.T., 61° 23'N 110° 15'W, 16/8/85. Northern Boreal Ecoregion, Northern Coniferous Ecodistrict. Open spruce-lichen woodland on small island, thin glacial till over bedrock. Evidence of mineral exploration by cratering adjacent to sample sites.

19. Eagle Lake, 59° 35'N 108° 30'W, 17/8/85. Northern Boreal Ecoregion, Northern Coniferous Ecodistrict. Northwest facing mature spruce-jackpine woodland on very thin glacial till, 500 m from road. Evidence of mineral exploration by trenching. Localized patches of uranium salts visible on bedrock exposed in some trenches.

20. Dunvegan Lake, N.W.T., 60° 07'N 107° 15'W, 18/8/85. Subarctic Boreal Ecoregion, Northern Transition Ecodistrict. North facing open spruce-lichen woodland on drumlinoid moraine.
21. Tazin River, 59° 48'N 108° 07'W, 19/8/85. Northern Boreal Ecoregion, Northern Coniferous Ecodistrict. Mature spruce forest on steep, north facing slope, glacial till over bedrock.
22. Ena Lake, 59° 51'N 108° 17'W, 21/8/85. Northern Boreal Ecoregion, Northern Coniferous Ecodistrict. Spruce-jackpine woodland, thin till over bedrock.

The three ecodistricts sampled (Athabasca South, Northern Coniferous and Northern Transition) follow SPRR (1983) for Saskatchewan and Rowe and Sheard (1981) for the N.W.T. Their climatic characteristics are summarized in Table 1 (see end of Materials and Methods section). Ecodistricts intergrade at their boundaries and of the three study regions only the Cluff Lake region has a central location in one of them, the Athabasca South Ecodistrict. This ecodistrict is a drift plain with prominent eskers, drumlins and sand dunes with regosolic soils at the sampling localities. Due to the cold climate and nutritionally-poor and well-drained soils, jackpine (Pinus banksiana) stands characterize the upland forests. These communities have an understory dominated by caribou lichens (primarily Cladina mitis) and scattered Canada blueberry (Vaccinium myrtilloides). Where soil moisture is more abundant, spruce (Picea mariana), feather moss (primarily Pleurozium schreberi) and labrador tea (Ledum groenlandicum) are common.

The Northern Coniferous and Northern Transition Ecodistricts have irregular bedrock-controlled topography and similar vegetation to each other and to the Athabasca South Ecodistrict, especially in the

relatively dry sites that were sampled to assure the presence of lichens. Wollaston Lake straddles the confluence of all three Ecodistricts and there were no distinct differences between the vegetation of the localities in the two Ecodistricts sampled within the Wollaston region (Athabasca South and Northern Coniferous). Similarly in the northernmost region, the Ena Lake, Tazin River and Dunvegan Lake localities were very close to the Northern Coniferous and Northern Transition Ecodistrict boundaries and no obvious vegetation differences were noted.

The three study regions lie within the Churchill Structural Province of the Canadian Shield (Schreiner 1984). Metamorphosed Precambrian basement rocks of the Western Craton, Mudjatik Domain and Wollaston Domain underlie most of the study area (MacDonald and Sibbald, 1986). The Uranium City and Eagle Lake localities are underlain by the Martin Lake Formation. The McInnes Lake locality in the N.W.T. is underlain by the Archean basement complex and middle proterozoic Nonacho Group (Nuri 1982). Sedimentary rocks of the Athabasca Group underlie the Midwest Road locality of the Wollaston region and all localities in the Cluff Lake region (Schreiner 1984).

There is uranium mineralization within each of the three regions; however, the extent of mineralization near individual localities varies. Four out of six localities in the northernmost Sask./N.W.T. region are near uranium deposits. The Uranium City locality in the northernmost region is about 1 km north of a uranium deposit that has been mined (Cinch Lake), and is very close to a minor deposit (Beck 1969). The Eagle Lake locality in the same region lies near three minor deposits and is about 2 km from the old Eldorado Eagle Lake underground workings. The McInnes Lake locality coincides with an economically significant

showing, which is in the midst of a general area of uranium mineralization (Nuri 1982). The Dunvegan Lake locality is northwest of a minor anomaly, according to an airborne gamma ray survey (GSC Survey 1977); however, the significance of this finding regarding recorded uranium mineralization has not been investigated on the ground. The Tazin Lake locality is about 3 km west of a minor surface showing (Beck 1969). There is no recorded uranium mineralization near the Ena Lake locality.

None of the Wollaston Lake localities are close to uranium mineralization (within 3 km). The Parks Lake locality is due east of the Rabbit Lake open-pit mine, but has no uranium mineralization on-site (Fuzesy 1982, 1986). There are radioactive boulder fields on the shore of Cunning Bay (2-3 km from the Cunning Bay locality), 5 km south of the Hidden Bay locality and about 5 km west of the Midwest Lake locality (Fuzesy 1982, 1986). The Hungry Island locality is near cordierite occurrences which are not considered significant metallogenically or geochemically (Fuzesy 1982, 1986). The Collins Creek, Minor Bay and Labach Lake localities have no recorded uranium showings nearby.

Although the Amok/Cluff Mining Ltd. uranium mine is in the middle of the Cluff Lake region, none of the Cluff Lake localities sampled in this study (with the exception of the Mill Site) are near uranium deposits (Tona et al. 1984).

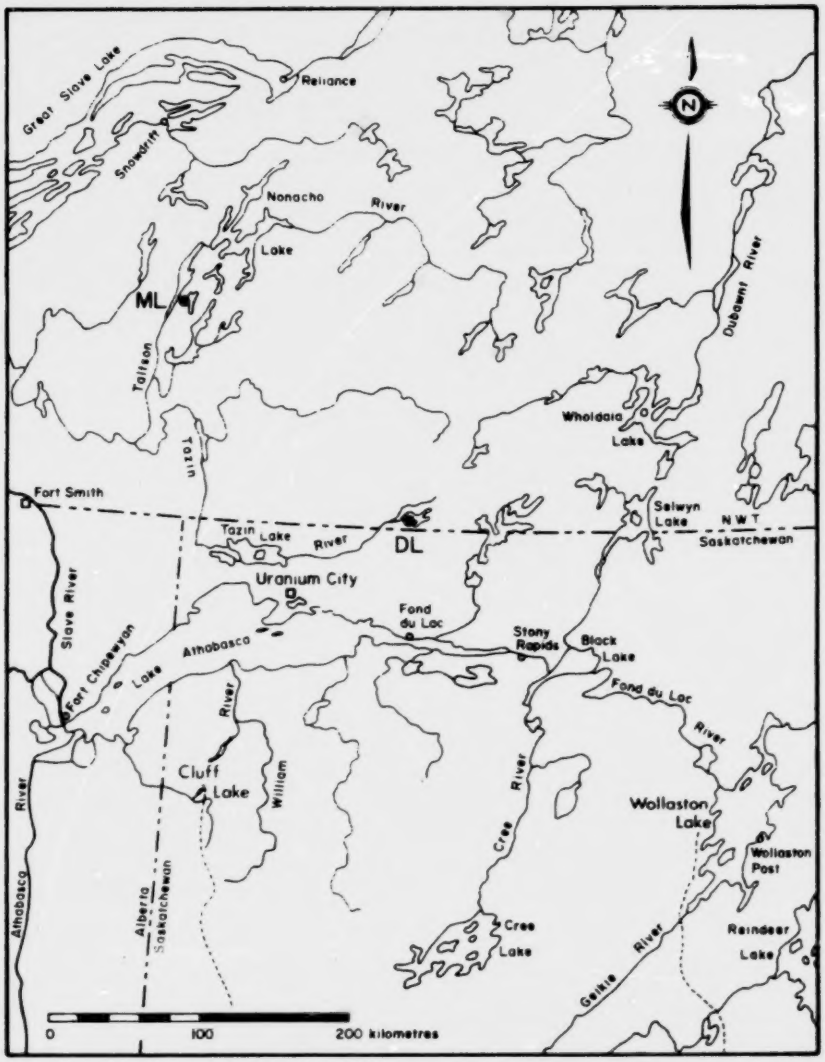


Figure 2. Northern Saskatchewan and adjacent Northwest Territories. Samples were collected in the Wollaston, Cluff Lake and Uranium City regions. Northwest Territory localities were Dunvegan Lake (DL) and McInnes Lake (ML).

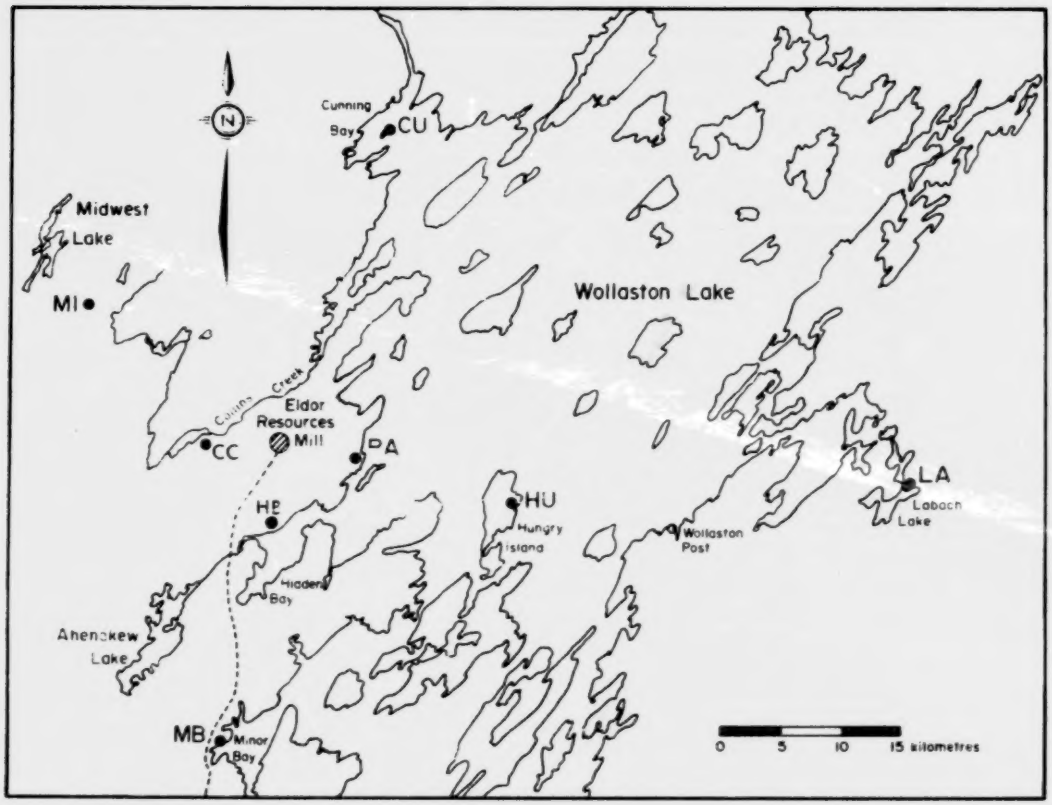


Figure 3. Wollaston Lake region sample localities:- Hidden Bay (HB), Collins Creek (CC), Hungry Island (HU), Cunning Bay (CU), Parks Lake (PA), Labach Lake (LA), Midwest Lake (MI) and Minor Bay (MB).

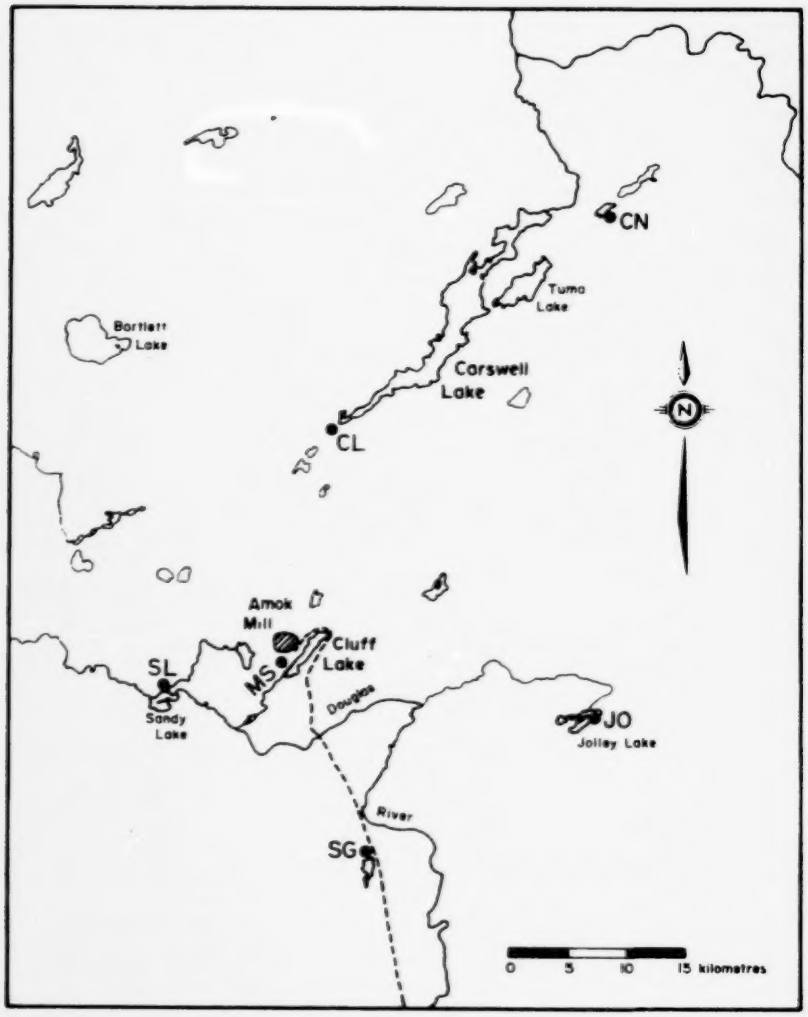


Figure 4. Cluff Lake region sample localities:- Carswell Lake (CL), South Gate (SG), Carswell North (CN), Jolley Lake (JO), Sandy Lake (SL) and Mill Site (MS).

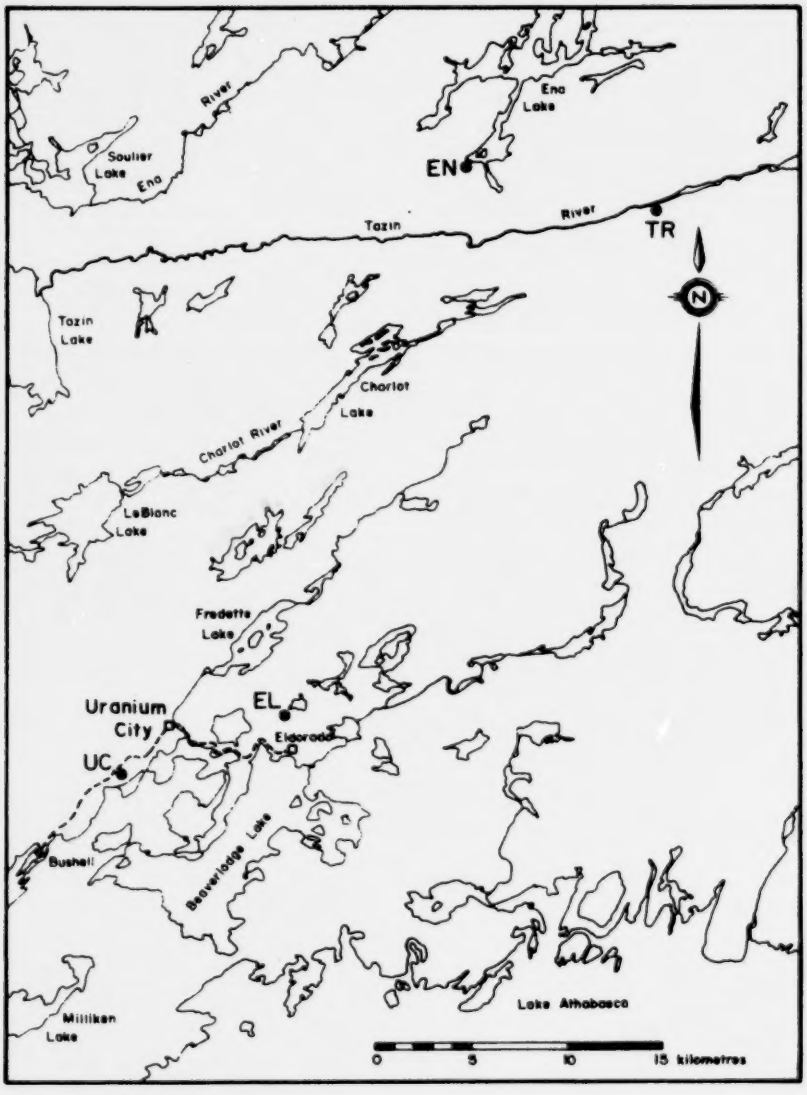


Figure 5. Northernmost Saskatchewan sample localities:- Uranium City (UC), Eagle Lake (EL). Tazin River (TR) and Ena Lake (EN). See Figure 2 for N.W.T. localities.

2.2 Sampling Procedures

Widely distributed species were selected in the hope that they would occur at the majority of localities in sufficient quantities to be sampled. A total of 18 species were collected although only one was found at all localities (Table 2). Two 200 g (dry weight) samples of each species were collected at each site and stored in polythene bags. The second samples were collected solely as back-up samples. Tree and shrub twigs were collected with garden clippers. The lichen and moss species were collected with teflon coated scissors to reduce the risk of metal contamination. All samples were dried by microwave oven within 48 hours of collection.

The terminal 15-25 cm of the tree and tall shrub branches were sampled. The needles or leaves of the conifers (Pinus banksiana and Picea mariana) and deciduous trees and tall shrubs (Betula neoalaskana, Populus tremuloides and Alnus crispa) were separated from the twigs. The conifer needles were analyzed since spruce needles are at the base of the spruce grouse food chain. An exception are the samples from Hidden Bay and Collins Creek collected for the preliminary study in 1983 and some other collections of 1985 due to a laboratory error, and which are noted in the results tables. The twigs (without leaves) of the deciduous trees and tall shrubs were analyzed since they are browsed by moose in winter and are the base of a food chain to man.

The terminal non-woody shoots of the shrubs, Vaccinium myrtilloides, V. uliginosum, Ledum groenlandicum, Arctostaphyllos uva-ursi and Juniperus communis were collected. Because of their small size the whole shoots (with leaves) of Vaccinium vitis-idaea and Empetrum nigrum were collected with scissors. A limited number of berry

fruiting shrub species (Vaccinium myrtilloides, V. vitis-idaea, Empetrum nigrum, Arctostaphyllos uva-ursi) were also collected.

The lichens were most easily collected in the morning when they were moist. Although time consuming, cutting the living portions away from the base of the lichen in situ minimizes the risk of contamination by soil particles and moss when collecting. These samples were cleaned of surficial organic detritus (leaves, conifer needles, twigs, etc.) when first dried and again, more carefully, prior to ashing.

Duplicate soil samples were collected at each of the three replicate sites at each locality. Soil pits were dug where possible but profiles were never well developed. The organic layer was removed from the soil surface and the top 2-5 cm of soil sampled as available. At a number of localities it was impossible to dig soil pits and samples were gathered from the surface of the bedrock. The two samples were bulked and air dried prior to chemical analysis. The resulting soils data are not suitable for detailed soil-plant transfer studies since the plants, unlike the soils, were gathered over a wide area within each site.

It was only possible to sample groundwater at a limited number of localities because this study focused on upland locations in groundwater recharge areas. Groundwater was sampled by digging a soil pit, emptying it of water and allowing it to fill a second time. Two and one half litre samples were taken, filtered through 0.45 um millipore filters under vaccum and acidified with 10% nitric acid on the day of collection, after return to base.

2.3 Chemical Analysis

Vegetation samples for Pb^{210} determination were wet-ashed by nitric-perchloric acid dissolution prior to analysis. Lead-210 activity was measured indirectly through its high energy beta-emitting daughter Bi^{210}. Samples for Ra^{226} and uranium determination were charred and then ashed at 500°C. Samples for Ra^{226} analysis were further treated by nitric-perchloric acid dissolution and Ra^{226} determined by barium sulphate precipitation followed by alpha counting. Soil samples for Pb^{210} and uranium analysis were treated by aqua-regia/perchloric acid dissolution and for Ra^{226} determination by pyrosulfate fusion, followed by the same analytical methods as the vegetation. The details of all the analytical techniques employed are described by Smithson (1979). Uranium was determined fluorometrically (HASL 1972). Detection limits for vegetation and soil samples were as follows:- Pb^{210} - 0.02 Bq/g, Ra^{226} - 0.005 Bq/g and uranium - 0.1 μg/g.

For the analysis of 21 stable elements the air dried vegetation samples were charred and ashed by nitric-perchloric acid dissolution. This solution was then subjected to inductively-coupled plasma spectrometry (ICP, Fassel & Kniseley 1974). Detection limits for stable elements are as follows: Ag, Be, Cd, Co, Cr, Cu, Fe, Mn, Ni, Ti, Zn < 0.2 μg/g; Ba < 0.5 μg/g; Al, Pb < 1.0 μg/g; B, Ca, Mg, V < 2.0 μg/g; K, Na, P < 10.0 μg/g.

Berry samples were treated by drying in a microwave oven in preparation for ashing. Unfortunately, excessive boiling over occurred, making use of the berry samples in further analysis impossible.

Specifications for internal quality controls at the S.R.C. analytical laboratory are given in Appendix I. In addition, for quality assurance purposes, blind duplicate samples from 20 of 23 batch runs

were submitted for chemical analysis. These are indicated in Table 2 and include most species and localities. The results and implications from this quality assurance program are discussed below.

Ten duplicate determinations of Pb^{210} and 37 duplicate determinations of Ra^{226}, uranium and the stable elements were performed. The results for the radionuclides are given in Table 3. The variation is calculated as the average percent deviation from the duplicate means. Lead-210 is the least variable and Ra^{226} the most variable. It is apparent that the variation of Ra^{226} is primarily due to the lichens (an explanation for this will be offered later). Otherwise the variation for the three radionuclides in the vascular plants and lichens is broadly comparable. The level of variation is comparable to that found in freshwater studies (Swanson 1985).

Comparisons for the stable elements (ICP analyses) were made by first standardizing the elements to z-scores and comparing the duplicates by pairwise t-tests over the 21 elements (Sokal and Rohlf 1981, p. 352). These showed eight significant differences (three lichens and five vascular plants), more than the two that would be expected due to chance alone, and with an over-representation among the lichens.

Replicate analysis of each sample would have reduced the data variability due to laboratory error, thereby making overall data interpretation easier.

It is important to understand that the variation due to chemical analyses will enter the error term in the statistical analyses of the results and will tend to reduce the number and significance of observed differences. Except where data that has not been statistically analyzed (raw data) are being interpreted, this source of variation will result

in a greater possibility of Type II errors (accepting a false null hypothesis); ie. real environmental relationships may be masked by the additional error.

2.4 Statistical Methods

2.4.1 Univariate Analyses

Univariate analysis of variance (ANOVA) was used to test the null hypothesis that for a given species and radionuclide the sample concentrations are distributed at random with respect to regions and localities within regions. One-way, nested ANOVA was applied as described by Sokal and Rohlf (1981). A minor complication was the fact that the number of replicates for regions was not always equal since all species were not present at all localities. The general linear model procedure (GLM, type III) of the Statistical Analysis System (SAS) program package (Ray 1982a, b) was used to carry out the analyses. The source of significant differences was determined by the Tukey-Kramer studentized multiple range test (Kramer 1956). Throughout the text the word significant implies statistical significance.

2.4.2 Multivariate Analyses

A major objective of the study was to detect any similar patterns of accumulation among the radionuclides and stable elements analyzed. A univariate approach could have been taken with each of the 21 stable elements analyzed but this would not necessarily have lead to a better understanding of co-variation between the elements and radionuclides. A multivariate approach to these problems was taken, since there is increasing recognition that a series of univariate tests is as

inappropriate for a multivariate problem as a series of t-tests for a univariate multi-group problem (Green 1980).

Many multivariate methods assume that the objects under study belong to a single population (Harris 1975, Pimentel 1978) and that the objective of the study is to determine relationships between objects within the population. In the present study there are a priori reasons to suppose that plant species are divisible into two groups with respect to radionuclide and element accumulation, the vascular plants (trees and shrubs) and non-vascular plants (lichens and mosses). The former take up nutrients and water primarily from the soil; the latter primarily from the air. Profile analysis (Morrison 1976) is one method by which multivariate comparisons between such groups can be made.

Profile analysis was selected for use in the present study. Following profile analysis, patterns of element accumulation were sought within the vascular and non-vascular plants separately using principal components analysis (PCA) and canonical correlation analysis (CCA). Finally canonical variates analysis (CVA) was applied to test for significant differences among localities and species based on the total number of radionuclides and stable elements. Details of these methods are to be found in the appendix, Section 8.2.

Each of the above multivariate methods was used for a different purpose, as each has its own restrictions. Principal components analysis, in contrast to methods of canonical analysis, suffers from the restriction that statistical tests of significance cannot be applied to the results. It was therefore used in a strictly heuristic sense; to generate rather than to test hypotheses. On the other hand, applications of canonical analysis (CCA and CVA) may be limited to interpretation in a small number of dimensions, corresponding to the

minimum number of variables in the two domains being studied. Canonical analyses may be used to test very specific hypotheses but their results may be less general and lead to fewer new insights than PCA. It was therefore considered appropriate to apply PCA as a summarization technique to obtain a broad understanding of data structure prior to application of the more restrictive methods of canonical analyses.

Table 1. Climate of ecodistricts (SPRR 1983) in the study area.

Ecoregion/ Ecodistrict	Precipitation (mm)		Temperature (^{o}C)		
	Total Annual	May-Sept.	Mean January	Mean July	Degree Days
1. Subarctic Boreal					
a) North Transition	369	208	-27.4	+15.0	1,020
2. Northern Boreal					
a) Athabasca South	390	249	-24.0	+16.9	1,090
b) Northern Coniferous	450	270	-23.7	+16.9	1,135

Table 2. Summary of vegetation samples and duplicate chemical analyses performed. Species names follow Scoggan (1957) for vascular plants, Hale and Culberson (1970) for lichens and Crum et al. (1973) for bryophytes.

Species Codes	Species group	Common name
1 *Vaccinium myrtilloides*	Shrub	Canada Blueberry
2 *Pinus banksiana*	Trees	Jackpine
3 *Ledum groenlandicum*	Shrub	Labrador Tea
4 *Alnus crispa*	Shrub	Green Alder
5 *Vaccinium vitis-idaea*	Shrub	Cranberry
6 *Picea mariana*	Tree	Black Spruce
7 *Cladina rangiferina*	Lichen	Caribou Lichen
8 *Cladina mitis*	Lichen	Caribou Lichen
9 *Pleurozium schreberi*	Moss	Feather Moss
10 *Cladina stellaris*	Lichen	Caribou Lichen
11 *Betula neoalaskana*	Tree	Paper Birch
12 *Stereocaulon paschale*	Lichen	Lichen
13 *Empetrum nigrum*	Shrub	Crowberry
14 *Cetraria nivalis*	Lichen	Lichen
15 *Populus tremuloides*	Tree	Trembling Aspen
16 *Arctostaphyllos uva-ursi*	Shrub	Bearberry
20 *Vaccinium uliginosum*	Shrub	Alpine Bilberry
21 *Juniperus communis*	Shrub	Common Juniper
2n *Pinus banksiana* (needles)		
6n *Picea mariana* (needles)		

Locality codes	
Wollaston Bay region	
1	Hidden Bay
2	Collins Creek
5	Hungry Island
6	Cunning Bay
7	Rabbit Lake
8	Labach Lake
9	Midwest Lake
10	Minor Bay
Cluff Lake region	
11	Carswell Lake
12	South Gate
13	Carswell North
14	Jolley Lake
15	Sandy Lake
16	Mill Site
N. Sask./N.W.T.	
17	Uranium City
18	Eagle Lake
19	Tazin River
20	Ena Lake
21	McInnes Lake
22	Dunvegan Lake

Symbols: - S, three replicate samples
–, no sample
*, duplicate Ra^{226}, uranium and stable element analysis
+, duplicate Pb^{210} analysis

Table 2 continued

Region/Locality	Wollaston Lake								Cluff Lake						N. Sask./NWT					
Species	1	2	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	S	S	*	S	–	S	S	S	+	S	S	*	*	S	–	–	–	–	–	–
2	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3	S	S	–	+	S	*	+*	S	–	–	–	–	–	–	S	S	*	S	S	S
4	–	S	+	–	S	–	–	S	S	+*	–	–	–	*	*	S	+	S	–	–
5	S	S	*	*	S	S	S	S	*	*	S	S	S	*	S	S	S	S	S	*
6	S	S	–	–	–	–	–	–	–	–	–	–	–	–	S	S	–	–	S	–
7	–	–	*	*	S	*	–	S	–	–	–	–	–	–	–	–	–	–	S	S
8	S	S	S	–	–	–	–	*+	S	S	S	S	S	S	*	*	S	S	–	–
9	S	S	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
10	S	S	S	S	*+	S	S	*+	–	–	–	–	S	–	–	–	–	–	S	S
11	–	–	S	S	S	–	–	–	–	–	–	–	–	–	S	+	S	S	S	S
12	–	–	–	*	S	*	*	–	–	–	–	–	–	–	–	–	–	–	–	–
13	–	–	–	–	–	S	S	–	–	–	–	–	–	–	–	–	–	–	*	*
14	–	–	–	–	–	–	*	–	–	–	–	–	–	–	–	–	–	–	–	–
15	–	–	–	–	–	–	–	–	S	–	–	–	–	–	–	–	–	–	–	–
16	–	–	–	–	–	–	–	–	–	–	–	–	–	*	S	–	–	–	–	–
20	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	S
21	–	–	–	–	–	–	–	–	–	–	–	–	–	–	S	–	–	–	–	–
2n	–	–	–	–	–	–	–	–	S	*	*	S	S	S	S	S	S	*	–	–
6n	–	–	S	S	S	*	S	S	*	–	S	*	–	–	S	S	S	S	–	*

Table 3. Precision of radionuclide analyses based on duplicate samples listed in Table 2.

	Detection limits	Range of duplicates	Plant Group	Variation n[1]	Variation x %[2]	Variation Range %[3]
Pb^{210}	0.02 Bq	0.02–0.20 Bq/g	vascular	7	9.0	0–14.3
		>0.20 Bq/g		–	–	–
		0.02–0.20 Bq/g	lichen	–	–	–
		>0.20 Bq/g		3	0	0
			Total	10	6.3	0–14.3
Ra^{226}	0.005 Bq	0.005–0.100 Bq/g	vascular	5	22.5	0–47.4
		>0.100 Bq/g		21	6.7	0–16.7
		0.005–0.100 Bq/g	lichen	–	–	–
		>0.100 Bq/g		11	37.1	0–63.9
			Total	37	17.4	0–63.9
Uranium	0.1 ug	0.1 – 1.0 ug/g	vascular	21	15.05	0–57.1
		>1.0 ug/g		5	9.3	3.2–24.6
		0.1–2.0 ug/g	lichen	–	–	–
		>1.0 ug/g		11	8.71	1.4–25.9
			Total	37	13.2	0–57.1

[1]Number of duplicates

[2]Average percent deviation from duplicate mean

[3]Range of duplicates expressed as a percentage deviation from means

3. PRELIMINARY DATA ANALYSIS

3.1 Conversion from ash to dry weights

Results of the chemical analyses of vegetation samples were initially reported on an ash weight basis, with the exception of the Pb^{210} analyses which were reported as dry weights. These data are listed in the Appendix, Section 8.3. Since one objective of the study was to identify plants at the base of food chains by which the radionuclides might be transferred to man, the ash weight concentrations were converted to dry weight concentrations and all further discussion in the report is based on average dry weights of the three replicate samples at each locality.

Average ash weights (of three replicates), expressed as a percentage of dry weight, for each species and locality are given in Tables 4-7. These average values were used to convert the original replicate ash weights to dry weights. It is evident from these tables that values of approximately 1% ash weight for lichens and 2.5% ash weight for trees, shrubs and mosses may be used for quick comparison to other studies in which results are presented as ash weights.

3.2 Data transformation

Parametric statistical analyses theoretically require that data be normally distributed. Normality was tested for all variables (three radionuclides and 21 stable elements) using procedure UNIVARIATE in SAS (Ray 1982a). This was done for both the dry weight data and the $\log_n (x + 1)$ transformed data applied to the deviates of the three replicates (Sokal and Rohlf 1981) for each species. For most variables the value of the Shapiro-Wilk statistic, W (sample size <51) or Kolomogorov statistic, D (sample size >50) improved after $\log_n$ transformation as did

the number of significantly normal distributions. In cases where improvement was only marginal, a final decision on transformation was made on the basis of improved skewness and/or kurtosis. Nineteen of twenty-four variables were $\log_n$ transformed (Table 8) and all further statistical analyses carried out on this new data set. No variable was rejected because it did not satisfy the statistical tests for normality. Experience suggests that many statistical techniques are, in fact, relatively robust to violations of this requirement provided the departures from normality are not large (Green 1980).

Sixteen of 24 variables had statistically normal distributions for 10 or more of the 18 species sampled. Uranium had the lowest number of statistically normal distributions with only three such species. Normality of all eighteen species improved after $\log_n$ transformation, some of them dramatically. The effect of transformation for one species and radionuclide in which the increase in the size of the W statistic is small and remains insignificant is demonstrated in Figure 6. In this purposely poor example of statistical improvement of normality, the normality of the frequency distribution is nevertheless considerably improved.

Table 4. Regional summary of percentage ash weights of oven dry vegetation samples; (n) needles, (nw) non-woody shoot, (w) woody shoot, (t) twigs.

Species	Wollaston Lake	Cluff Lake	N. Sask. /N.W.T.	Mean
P. banksiana (n+t)	2.34	-	-	2.34
P. mariana (n+t)	2.42	-	2.07	2.25
B. neoalaskana (t)	1.28	-	1.57	1.42
P. tremuloides (t)	-	3.45	-	3.45
P. banksiana (n)	-	2.46	2.05	2.25
P. mariana (n)	2.28	2.85	2.20	2.44
			trees	2.40
V. myrtilloides (nw)	2.91	3.35	-	3.13
L. groenlandicum (nw)	2.67	-	2.52	2.59
A. crispa (t)	2.27	2.68	2.42	2.46
V. vitis-idaea (w)	2.86	3.21	2.62	2.90
E. nigrum (w)	2.67	-	2.37	2.52
A. uva-ursi (nw)	-	3.25	2.90	3.07
V. uliginosum (nw)	-	-	2.47	2.47
J. communis (nw)	-	-	3.63	3.63
			shrubs	2.85
C. rangiferina	1.10	-	0.75	0.93
C. mitis	1.13	1.26	1.03	1.14
C. stellaris	1.15	1.16	0.53	0.95
S. paschale	1.17	-	-	1.17
C. nivalis	1.19	-	-	1.19
			lichens	1.07
P. schreberi	2.45	-	-	2.45

Table 5. Percentage ash weights of oven dry vegetation samples, Wollaston Lake localities.

Species	Midden Bay	Collins Creek	Hungry Island	Cunning Bay	Parks Lake	Labach Lake	Midwest Lake	Minor Bay	Mean
P. banksiana	2.34	-	-	-	-	-	-	-	2.34
P. mariana	2.59	2.26	-	-	-	-	-	-	2.42
B. neoalaskana	-	-	1.13	1.48	1.24	-	-	-	1.28
P. mariana (n)	-	-	2.20	2.29	2.22	2.41	2.40	2.18	2.28
								trees	1.98
V. myrtilloides	3.13	2.88	2.63	2.52	-	2.95	3.00	3.25	2.91
L. groenlandicum	2.97	2.79	-	2.65	2.53	2.72	2.45	2.58	2.67
A. crispa	-	3.15	1.71	-	2.16	-	-	2.06	2.27
V. vitis-idaea	2.69	3.13	2.81	2.91	2.69	2.99	3.00	2.65	2.86
E. nigrum	-	-	-	-	-	2.59	2.76	-	2.67
								shrubs	2.68
C. rangiferina	-	-	1.05	1.06	1.05	1.17	-	1.18	1.10
C. mitis	1.14	1.02	1.00	-	-	-	-	1.34	1.13
C. stellaris	0.97	0.69	1.11	1.21	1.24	1.29	1.26	1.42	1.15
S. paschale	-	-	-	1.14	1.19	1.24	1.11	-	1.17
C. nivalis	-	-	-	-	-	-	1.19	-	1.19
								lichens	1.15
P. schreberi	2.71	2.19	-	-	-	-	-	-	2.45

Table 6. Percentage ash weights of oven dry vegetation samples, Cluff Lake localities.

Species	Carswell Lake	South Gate	Carswell North	Jolley Lake	Sandy Lake	Mill Site	Mean
P. tremuloides	3.45	-	-	-	-	-	3.45
P. banksiana (n)	2.48	2.46	2.34	2.36	2.26	2.85	2.46
P. mariana (n)	2.37	-	3.15	3.04	-	-	2.85
						trees	2.92
V. myrtilloides	3.27	2.99	3.30	3.39	3.25	3.90	3.35
A. crispa	3.13	2.62	-	-	-	2.29	2.68
V. vitis-idaea	3.32	3.05	3.19	2.84	2.94	3.94	3.21
A. uva-ursi	-	-	-	-	-	3.25	3.25
						shrubs	3.12
C. mitis	1.13	1.21	1.13	1.19	1.02	1.89	1.26
C. stellaris	-	-	-	-	1.16	-	1.16
						lichens	1.21
			Fire Samples				
P. banksiana (n)	-	2.03	2.41	1.76	1.93	2.37	2.10
V. myrtilloides	-	2.91	3.33	2.97	2.99	3.66	3.17

Table 7. Percentage ash weights of oven dry vegetation samples, northernmost Saskatchewan/N.W.T. localities.

Species	Uranium City	Eagle Lake	Tazin River	Ena Lake	McInnes Lake	Dunvegan Lake	Mean
P. mariana	2.05	2.25	-	-	1.90	-	2.07
B. neoalaskana	2.03	1.50	1.37	1.60	1.63	1.27	1.57
P. banksiana (n)	2.07	2.03	2.13	1.97	-	-	2.05
P. mariana (n)	2.40	1.90	2.27	2.30	-	2.13	2.20
						trees	1.92
L. groenlandicum	2.90	2.67	2.50	2.43	2.27	2.33	2.52
A. crispa	3.03	2.07	2.53	2.03	-	-	2.42
V. vitis-idaea	2.67	2.43	2.77	2.80	2.60	2.47	2.62
E. nigrum	-	-	-	-	2.50	2.23	2.37
A. uva-ursi	2.90	-	-	-	-	-	2.90
V. uliginosum	-	-	-	-	-	2.47	2.47
J. communis	3.63	-	-	-	-	-	3.63
						shrubs	2.70
C. rangiferina	-	-	-	-	0.67	0.83	0.75
C. mitis	1.33	1.10	0.87	0.83	-	-	1.03
C. stellaris	-	-	-	-	0.47	0.60	0.53
						lichens	0.77

Table 8a. Summary statistics for dry weight vegetation data. + indicates ln(x+1) transformation of variable, - indicates no transformation.

Variable	ln	Minimum Value	Maximum Value	Mean	Standard Deviation
Pb^{210} Bq/g	+	<.02	0.742	0.135	0.127
Ra^{226} Bq/g	+	0.0002	0.610	0.017	0.044
Uranium µg/g	+	<.001	3.233	0.236	0.472
Boron µg/g	+	0.066	4.007	1.782	1.010
Phosphorus µg/g	-	89.070	2213.400	856.568	319.398
Silver µg/g	+	<.002	0.777	0.120	0.135
Aluminum µg/g	+	2.255	6.722	4.939	0.923
Beryllium µg/g	+	0.004	0.120	0.024	0.020
Calcium µg/g	-	170.940	12291.780	4319.880	2729.172
Cadmium µg/g	+	0.006	0.877	0.078	0.103
Cobalt µg/g	+	0.009	0.894	0.083	0.110
Chromium µg/g	-	0.038	2.862	0.335	0.218
Copper µg/g	+	0.231	2.565	1.211	0.528
Iron µg/g	+	1.018	5.878	4.093	0.833
Potassium µg/g	-	242.000	5581.720	2147.566	1048.480
Magnesium µg/g	+	4.489	7.865	6.570	0.771
Manganese µg/g	+	1.965	8.545	5.688	1.486
Sodium µg/g	+	1.292	4.976	2.956	0.665
Nickel µg/g	+	0.104	2.035	0.580	0.333
Lead µg/g	+	0.025	1.758	0.297	0.335
Titanium µg/g	+	<.002	2.551	1.052	0.692
Vanadium µg/g	+	0.164	1.100	0.568	0.187
Zinc µg/g	-	6.216	308.000	33.036	30.723
Barium µg/g	+	0.515	4.649	2.348	0.752

Table 8b. Summary statistics for dry weight soil data. + indicates ln(x+1) transformation of variable, - indicates no transformation.

Variable	ln	Minimum Value	Maximum Value	Mean	Standard Deviation
Pb^{210} Bq/g	+	0.020	1.386	0.085	0.160
Ra^{226} Bq/g	+	0.005	1.946	0.057	0.215
Uranium μg/g	+	0.262	6.875	0.787	0.829
Boron μg/g	+	1.792	4.796	2.718	1.225
Phosphorus μg/g	-	20.000	840.000	182.938	182.435
Silver μg/g	+	0.405	0.993	0.413	0.065
Aluminum μg/g	+	5.525	9.904	7.798	1.223
Beryllium μg/g	+	0.405	1.609	0.842	0.358
Calcium μg/g	-	<.02	2600.000	633.222	559.631
Cadmium μg/g	+	0.405	1.792	0.433	0.157
Cobalt μg/g	+	0.405	4.205	0.949	0.602
Chromium μg/g	-	9.900	450.000	196.369	99.428
Copper μg/g	+	0.693	4.511	1.608	0.733
Iron μg/g	+	6.909	9.741	8.266	0.687
Potassium μg/g	-	<.1	1600.00	562.531	511.182
Magnesium μg/g	+	2.996	8.537	5.639	1.462
Manganese μg/g	+	<.002	6.889	3.482	1.164
Sodium μg/g	+	3.714	6.909	5.317	0.821
Nickel μg/g	+	1.194	4.443	2.191	0.570
Lead μg/g	+	1.099	4.344	1.958	0.689
Titanium μg/g	+	2.565	6.825	4.831	1.393
Vanadium μg/g	+	1.792	4.220	2.326	0.585
Zinc μg/g	-	<.002	86.000	11.185	14.196
Barium μg/g	+	1.932	5.352	3.224	0.819

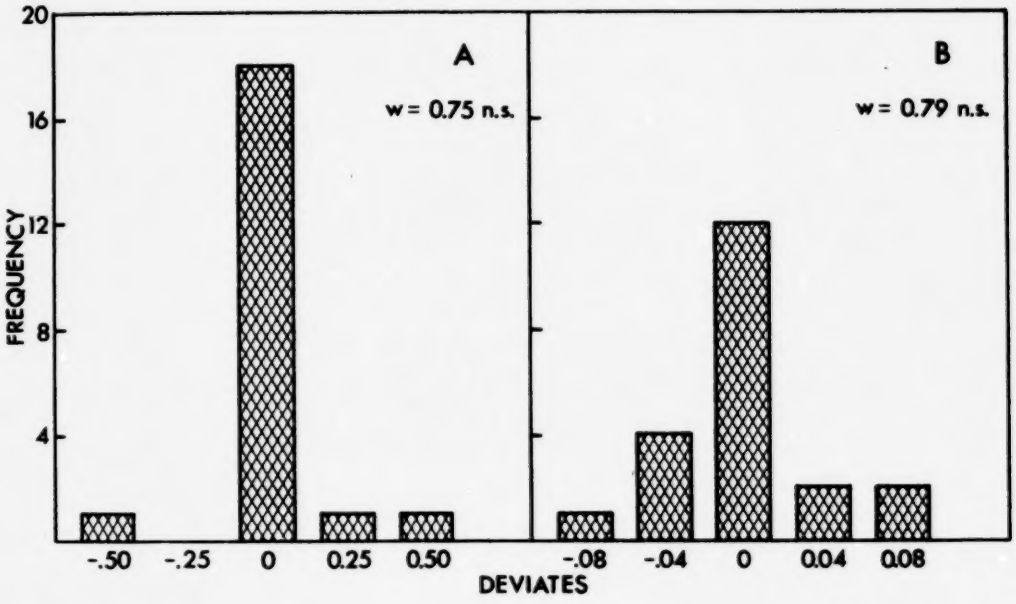


Figure 6. Uranium frequency plot of deviates for the lichen Cladina stellaris, a) before and b) after $\log_n$ transformation. W is the Shapiro-Wilk statistic (Shapiro and Wilk 1965).

4. RESULTS

4.1 Univariate Analyses

Radionuclide concentrations in vegetation samples are presented on a dry weight basis throughout this report. Tables for each radionuclide (placed at the end of the Results section) summarize arithmetic mean concentrations for each species group and species within a region, and the average of three replicates of each species at each sample locality within each region. Since species do not all occur in every locality, or even in all regions, group means represent the available species means weighted by their number of samples. Locality vegetation means are weighted by group means within the locality. Region vegetation means are the average of their locality means and in this sense are also weighted by group means. Summary tables (9, 14 and 19) do not have levels of significance or confidence limits attached to them because the means are calculated (partially) over different species and localities. Other tables include the results of nested one-way analysis of variance (ANOVA) carried out on transformed (see Table 8) species and soil data.

4.1.1 Lead-210

The Wollaston Lake region has marginally the highest average vegetation concentration of Pb^{210} (0.20 Bq/g, Table 9) but this is mainly attributable to moss, sampled only in this region. Among species groups, the vascular plants have considerably lower concentrations of Pb^{210} than the lichens (0.06 and 0.08 Bq/g compared to 0.38 Bq/g) indicating that the atmosphere is the direct source of this radionuclide in all regions.

The individual species are compared among the regions in Table 10; two lichens show significant differences due to high values in the Wollaston Lake region. Paper birch (Betula neoalaskana) has the highest average concentration among the trees (0.10 Bq/g) and Canada blueberry (Vaccinium myrtilloides) has the highest concentration (average 0.14 Bq/g) of the shrub species. The lichen, Cetraria nivalis (0.53 Bq/g), and the moss, Pleurozium schreberi (0.55 Bq/g), have the highest average concentrations but these values are biased in the sense that these species were only sampled in the Wollaston Lake region.

Differences between localities within regions are compared in Tables 11-13. Within the Wollaston Lake region, the Collins Creek locality has the highest average accumulation (0.34 Bq/g, Table 11). This locality is the source of significant differences for two species, black spruce (Picea mariana) and blueberry (Vaccinium myrtilloides), the latter having the highest recorded value (0.27 Bq/g) among the vascular plants. The Mill Site locality (average 0.24 Bq/g, Table 12) is the source of most variance in the Cluff Lake region but again only two species show significant differences; blueberry (V. myrtilloides, 0.18 Bq/g) and the caribou lichen Cladina mitis (0.47 Bq/g). Eagle Lake has the highest average concentration (0.27 Bq/g) in the northernmost region (Table 13) and is the basis for the only significant difference, green alder (Alnus crispa, 0.16 Bq/g), found in the region.

In summary, the lichens have the highest average concentration of Pb^{210}. The three caribou lichens were the most widely sampled species and where they occur together they accumulate Pb^{210} in the order Cladina stellaris > C. mitis > C. rangiferina. This corresponds to their decreasing surface area/unit biomass as indicated by their degree of branching. Cetraria nivalis, another lichen, has strap shaped branches

with a relatively greater surface area than the other lichens. In the one locality where it was collected (Wollaston Lake region) this species had the highest level of Pb^{210}. These facts are all consistent with the hypothesis that lichens accumulate Pb^{210} primarily from the atmosphere (ultimately derived from radon emanation from the soil). The contribution from soil particles suspended in the air is likely to be very small in a forest habitat with a closed ground canopy.

4.1.2 Radium-226

The northernmost Saskatchewan and N.W.T. region has the highest average concentration of Ra^{226} in vegetation (0.031 Bq/g), corresponding to a soil concentration (0.387 Bq/g) which is one order greater than for other regions (Table 14). The shrubs in this region have approximately twice the average accumulation (0.028 Bq/g) of the trees and lichens. This suggests that atmospheric distribution of Ra^{226} is not of general importance in the natural environment.

No species or soil shows a significant difference in Ra^{226} concentration among the three regions despite the relatively large variations in regional averages (Table 15). Paper birch (Betula neoalaskana) has the highest average concentration (0.033 Bq/g) of the tree species and bearberry (Arctostaphyllos uva-ursi, 0.068 Bq/g) and Labrador tea (Ledum groenlandicum, 0.046 Bq/g) have the highest concentrations among the shrubs. The lichen Cladina mitis has an average accumulation of 0.018 Bq/g, comparable with some shrub species, but this is weighted by a high average value for the Cluff Lake region (due to the Mill Site, see Table 17).

The regions have a number of significant differences among localities (Tables 16-18). Within the Wollaston Lake region the Parks

Lake locality has an average Ra^{226} concentration (0.016 Bq/g) approximately twice that of the other localities due primarily to high lichen concentrations (Table 16), two of which are significantly different from other localities. The concentration of Ra^{226} in the lichen Stereocaulon paschale is one order larger than at three other locations in the region. Three vascular species show significant differences between Wollaston localities other than Parks Lake; however, Labrador tea (Ledum groenlandicum) which has the highest average concentration (0.019 Bq/g), did not differ between localities.

The Mill Site locality at Cluff Lake has an average concentration (0.068 Bq/g) one order larger than at the other localities and all five species sampled there have significantly higher accumulations of Ra^{226} (Table 17). The caribou lichen Cladina mitis has the highest concentration (0.149 Bq/g) at the Mill Site. It is important to note that the soil concentration at this site is the lowest recorded (0.010 Bq/g) for the Cluff Lake region. This suggests that high vegetation levels of Ra^{226} at the Mill Site are due to anthropogenic activity. Variation between the other localities is insignificant.

In the northernmost region, the Eagle Lake locality has accumulations approximately one order of magnitude larger than other localities (0.121 Bq/g), corresponding to soil concentrations up to two orders of magnitude larger (Table 18). Labrador tea (Ledum groenlandicum) again possesses the highest average value (0.074 Bq/g) and the highest concentration recorded at Eagle Lake (0.359 Bq/g).

In summary and in contrast to Pb^{210}, the highest natural concentrations of Ra^{226} are shown by shrubs rather than lichens. In most localities where it occurs, the shrub Ledum groenlandicum has the highest accumulation. The Eagle lake locality in the northernmost

region has the highest average Ra^{226} concentration for both the soil and vegetation.

4.1.3 Uranium

The Cluff Lake region has the highest average vegetation concentration for uranium (1.347 μg/g, Table 19). It is notable also that the lowest average plant concentration is for northernmost Sask./N.W.T. (0.048 μg/g), the region that has the highest soil concentration (57.711 μg/g) by approximately two orders of magnitude. The lichens, as for Pb^{210}, have the highest concentration of the three plant groups (0.847 μg/g).

Black spruce (*Picea mariana*), bearberry (*Arctostaphyllos uva-ursi*), and soil show significant differences among regions (Table 20). The highest average concentrations for vascular species that were present in more than two localities and two or more regions are jackpine needles (*Pinus banksiana*, 0.279 μg/g) among the trees and blueberry (*Vaccinium myrtilloides*) (0.465 μg/g) among the shrubs (see also Tables 21-23). However, crowberry (*Empetrum nigrum*) has the highest levels at the four localities where it was sampled in the Wollaston Lake and northernmost Sask./N.W.T. regions (Table 21 and 23 respectively). These levels are lower than comparable values for the lichens, for example 1.657 μg/g in *Cladina mitis*. The moss *Pleurozium schreberi* has a very high value (3.071 μg/g) but the result is biased by the fact that this species was only sampled at the two Wollaston Lake localities with the highest average accumulations over all species.

Localities within regions are compared in Tables 21-23. Within the Wollaston Lake region three localities, Collins Creek (1.757 μg/g), Parks Lake (1.510 μg/g) and Hidden Bay (1.469 μg/g), have high average

concentrations of uranium (Table 21). The Parks Lake site is somewhat anomalous in that the average accumulation for the lichens is 19.0 times that for the shrubs. In comparison, the average concentration for the lichens is 8.9 times that for the shrubs at the remaining sites in the region (maximum of 11.4 times at Minor Bay).

Eleven species and the soil showed significant differences between localities in the Wollaston region. The highest average vascular plant accumulation was blueberry (Vaccinium myrtilloides, 0.203 μg/g); being much lower than the average concentration in the most frequently sampled lichen, Cladina stellaris (1.527 μg/g).

In the Cluff Lake region the Mill Site has significantly larger accumulations for all sampled species and has an average uranium concentration (7.680 μg/g) one order of magnitude larger than for the other sites in the region (Table 22). This locality is responsible for the high average vegetation concentration for the Cluff Lake region. The shrub Vaccinum vitis-idaea (cranberry) and the lichen Cladina mitis also show significant differences for the Carswell North and Sandy Lake localities which have the lowest and second highest concentrations respectively.

Eagle Lake has the highest average concentration (0.168 μg/g) among the northernmost Sask./N.W.T. localities (Table 23). Six species show significant variation among the localities, the four occurring at Eagle Lake all having their highest values at that locality. The soil concentration for this locality (324.7 μg/g) is at least two orders of magnitude larger than encountered at all other study localities.

In summary, jackpine needles (Pinus banksiana) have the highest concentration of uranium among the trees tested and exceed paper birch (Betula neoalaskana) in this regard, which has the highest average for

Pb^{210} and Ra^{226}. Crowberry (Empetrum nigrum) has the highest shrub accumulation; however, it occurred at only four localities. Among the shrubs present in at least two regions, the species with the highest average concentration is blueberry (Vaccinium myrtilloides). Lichens have the highest concentration of uranium of the three main plant groups. Accumulation of uranium from the atmosphere is implicated, as the uptake sequence in lichens is identical to that for Pb^{210}: Cetraria nivalis > Cladina stellaris > C. mitis > C. rangiferina.

4.1.4 The Influence of Fire

Fire occurs frequently and hence has a major impact on vegetation in the study area. Burn sites less than 20 years old have less diverse vegetation than older sites and no lichens suitable for sampling. Thus fire, or the lack of it, had a major impact on the choice of sample sites. Sites were often islands or headlands on lakeshores that were protected from burning.

The sandy and dry soil in the Cluff Lake region causes an impoverished flora and difficulty was experienced in finding eight species to sample at each locality. Because of the particularly high fire return frequency in this area all localities except Carswell Lake had burns immediately adjacent to them. This provided an opportunity to sample and compare two vascular species, jackpine (Pinus banksiana) and blueberry (Vaccinium myrtilloides), in recently burned (4-12 years old) and unburned situations (Table 24). (Note: The means in Table 24 exclude the Mill Site to avoid weighting due to the elevated radionuclide concentrations at this locality which are probably associated with uranium mining operations.)

Both vascular species have lower concentrations of Pb^{210} and uranium in the burned sites (Table 24). Although not significant ($P > .05$), the consistency of the differences (Tables 12 and 22 respectively) may suggest a real trend due to loss of these radionuclides from the rooting zone of the soil. This is supported by a significant decrease in soil uranium. However, Pb^{210} levels in the burn soil increase.

In contrast to Pb^{210} and uranium, Ra^{226} concentrations in blueberry (Vaccinium myrtilloides) significantly increase in the burned sites. Jackpine (Pinus banksiana) and soil Ra^{226} levels decline (Table 24).

It is not possible to explain these results. One difficulty is that although the fire sites are adjacent to the unburned sites there is no guarantee that they are otherwise identical. The effect of fire would be best studied before and after controlled burning.

4.1.5 Groundwater

An attempt was made to collect groundwater but, since the study was based on upland vegetation, this was only possible at five localities due to deep water tables. In addition, data from permanent test wells close to the Mill Site locality, Cluff Lake region, were obtained. The results are summarized in Table 25 and indicate that higher groundwater concentrations of Ra^{226} and uranium are found at localities close to ore bodies.

In other respects Table 25 should be interpreted with caution because the groundwater samples were generally not taken from any of the three replicate sample sites but from sites as close to them as possible. Depending on the direction of groundwater flow, which can only be inferred, they may or may not have relevance to the vegetation

sampled. The data from each locality must therefore be considered individually, and on the basis of the site descriptions in field notes:

Hidden Bay: Groundwater was sampled from a soil pit in a seepage area at the base of the esker from which vegetation samples were collected, but 200 m from the nearest replicate site. Groundwater radionuclide levels are the lowest recorded whereas the vegetation levels for Pb^{210} and uranium are among the three highest average locality levels for vegetation.

Midwest Lake: One sample was collected from a natural pool between boulders at the base of a very gentle slope below one replicate site. This was probably the most representative sample of groundwater collected with respect to the sampled vegetation. Groundwater radionuclide levels equal those for the above Hidden Bay locality as the lowest recorded concentrations. Concentrations of Pb^{210} and Ra^{226} in vegetation are average and below average respectively, and for uranium below average (excluding the northernmost Sask./N.W.T. region).

Uranium City: Groundwater was collected from a soil pit in a seepage area occupying a bedrock controlled depression below one sample site. This groundwater sample has the highest recorded radionuclide levels except for Pb^{210}. Vegetation concentrations are below average and average for Pb^{210} and uranium respectively, and the second highest recorded for Ra^{226}.

Eagle Lake: A water sample was collected from a soil pit in a Sphagnum bog adjacent to one collection site. The sample has the highest concentration of Pb^{210} recorded and second highest levels of Ra^{226} and uranium. Labrador tea (Ledum groenlandicum) samples were collected at this point and have average values for Pb^{210}, the

highest recorded value for Ra^{226} (0.359 Bq/g) and an average concentration of uranium. The locality also has the highest average vegetation concentration of Ra^{226} by a factor of five.

Ena Lake: Groundwater was sampled from a spring at the base of an esker 300 m from the closest replicate site. The sample has radionuclide concentrations as low as the Hidden Bay and Midwest Lake localities. Vegetation accumulations are average for Pb^{210} and amongst the lowest recorded for Ra^{226} and uranium.

In summary, Pb^{210} and uranium concentrations in the groundwater samples tended to show an inverse relationship to concentrations in vegetation. In contrast, Ra^{226} levels were considerably elevated at the Uranium City and Eagle Lake localities, which had the highest groundwater as well as soil levels sampled.

4.2 Multivariate Analysis

Analysis of variance (ANOVA) was used in the previous section to detect differences between regions and between localities within regions by analyzing one species and radionuclide at a time. However, ANOVA did not statistically address the question of variation among species groups or individual species although some insight was gained, particularly at the species group level, by simple tabulation of results.

In comparing species, the interest lies in comparison over all localities rather than within the individual localities. Two-way ANOVA (species versus locality) would have been the preferential method of analysis had it not been for the fact species do not occur at all localities. Such unbalanced designs create severe statistical difficulties. We were also interested in whether or not the radionuclides correlate with the stable elements in the vegetation

sampled. The comparison of elements and species was simultaneously assessed by application of multivariate statistical methods.

In the present study the multiple variables are the elements and the vegetation samples are the observations for comparison. The data are assembled in a two dimensional matrix of variables by observations, the observations being vegetation samples for each species (three replicates) at each locality (for a summary of stable element data see Appendix, Section 8.4). In order to reduce the size of the matrix and to improve the normality of the data, the replicates were averaged prior to $\log_n$ transformation of the variables indicated in Table 8. The size of the matrix used for the initial multivariate analysis (profile analysis) was 23 variables x 437 observations. See Appendix 8.2 for a detailed discussion of multivariate methods.

4.2.1 Profile Analysis

The accumulation of radionuclides and elements over all localities was compared simultaneously for the vascular and non-vascular species using profile analysis. This involves pooling the species within each species group and comparing their mean values for each radionuclide and stable element. These data are plotted in Figure 7. The intersecting profiles imply different uptake mechanisms for the set of radionuclides and stable elements in the two groups. The null hypothesis of similar (parallel) response patterns is statistically rejected ($P<0.0001$). Since parallelism is rejected, the remaining two test hypotheses of profile analysis (see Appendix, Section 8.2) do not apply.

The non-vascular plants have high concentrations of the crust-derived and atmospherically-transported elements titanium, iron, aluminum, vanadium, chromium, Pb^{210} and sodium (Puckett and Finegan

1980, Sheard 1986b). Lead-210 is at one extreme of the profile and is the element for which atmospheric distribution is the most dominant. Uranium, stable lead, and beryllium are the remaining elements which are preferentially accumulated by the non-vascular plants. The association of uranium with atmospherically distributed elements indicates an atmospheric pathway for most uranium accumulated by the lichens.

At the other end of the profiles, zinc and the last seven elements (potassium, boron, calcium, phosphorus, copper, manganese and potassium) are essential nutrients for the faster-growing vascular plants and are selectively or passively (non-selectively) cycled to and from the soil. Some non-essential elements such as uranium, cadmium and silver also tend to be passively cycled (Delwich 1983); the latter two are among the elements that occupy the middle range of the profiles.

Radium-226 occupies the middle of the profile and is well removed from calcium with which it shares chemical similarity. It is notable that Ra^{226} is much closer to barium, especially for the vascular plants.

Profile analysis confirms the a priori reasoning that the vascular and non-vascular plant samples should not be treated as belonging to the same population where element concentrations are concerned. The two plant groups are therefore treated separately in the following principal components analyses.

4.2.2 Principal Components Analysis (PCA)

Principal components analysis was carried out separately on the vascular and non-vascular samples following the results of profile analysis. The PCA results on the vascular species are presented in Appendix 8.5, Table 26, and Figure 8. A large proportion (72%) of the total variance in the data-set is accounted for by the first six

components. All the elements, except sodium, have greater than 50% of their variance accounted for. Therefore, most stable elements and all three radionuclides make important contributions to the first six components.

Seven elements have high correlations (> 0.65, also called high loadings) with the first component (or axis) (Table 26 and Appendix 8.5). When the scores (the positions with respect to the components) for the vegetation samples are ordinated on the components (Figure 8a, b) it is clear that these elements have high concentrations in blueberry (Vaccinium myrtilloides) samples from the Cluff Lake region (see also Appendix, Section 8.4). Note, however, that this species was not collected in the northernmost region; comparison is only possible with the Wollaston Lake region. V. myrtilloides samples from Wollaston also have positive, but lower scores, on the first component. It would appear that V. myrtilloides is responding uniquely to a feature of the soils of the Cluff Lake region that makes the seven elements relatively more available than at Wollaston Lake. The very high loading for boron indicates that the component represents essential nutrients and other elements that are taken up non-selectively and passively cycle through vascular plants (Delwich 1983).

The second component has high loadings for nickel, copper and cobalt (Table 26) and a very high score for green alder (Alnus crispa) at Eagle Lake (Figure 8a, b). The high Alnus scores reflect the high concentrations of cobalt (mean 0.358 μg/g) in this species, a required element in the nitrogen fixing process associated with its roots (Devlin and Witham 1983). The second component also has relatively high loadings for Ra^{226}. These loadings are responsible for the high scores for paper birch (Betula neoalaskana) and Labrador tea (Ledum groenlandium) at Eagle Lake. Radium-226 concentrations for these two

species at Eagle Lake are 0.255 Bq/g and 0.359 Bq/g respectively. Lead-210 is responsible for the relatively high score for blueberry (Vaccinium myrtilloides) at Collins Creek (concentration of 0.27 Bq/g). The conifers have the lowest scores on the second component, reflecting the low concentrations of both copper and Ra^{226} in these species.

The scores for the third and subsequent components have not been ordinated but the results are summarized in Table 26. Uranium is the only radionuclide associated with any of these components. It is highly correlated with the sixth component and separates all vascular samples collected at the Mill Site, Cluff Lake region.

The PCA results on the non-vascular species are given in Appendix 8.6, Table 27, and Figure 9. In terms of variance accounted for, the analysis was more successful than that on the vascular species. The first six components account for 86% of the variance. All elements except boron and zinc have greater than 70% of the variance accounted for. The radionuclides are again important sources of variation in the analysis.

Eight elements have high correlations with the first component (>0.70, Table 27 and Appendix 8.6). Each has a high concentration in all samples except those from the six northernmost localities. The very high loading for titanium suggests that this component positively correlates with crust-derived elements. The two Northwest Territory localities (McInnes and Dunvegan Lakes) have the lowest scores on the first component (Figure 9b), and the next two most northerly localities (Ena and Tazin Lakes) also have relatively low scores.

The second component has high correlations (>0.75) for seven elements (Table 27 and Appendix 8.6), all of which are essential

nutrients, and are associated with the moss (Pleurozium schreberi) samples at the two localities where it was collected (Figure 9c).

Radium^{226} and silver have the highest correlations with the third component, which separates the Mill Site (caribou lichen, Cladina mitis) from all other localities (Table 27). Uranium also has a relatively high correlation with the third component. Lead-210 is correlated with component five and separates the three Collins Creek samples (concentrations of 0.43-0.67 Bq/g). Uranium has the next highest correlations and also has high concentrations for these samples (Appendix 8.6).

The two principal component analyses demonstrate that the radionuclides are not the major source of variance in the vegetation samples from the three regions studied. For the vascular plants the major source of variance (24%) is a set of essential and passively cycled elements which separate blueberry (Vaccinium myrtilloides) in the Cluff Lake region from all other samples. Similarly, for the non-vascular plants the separation of the four northernmost localities with low concentrations of crustal elements accounts for the major source of variance (29%).

4.2.3 Canonical Correlation Analysis (CCA)

Principal components analysis did not show any strong correlations between the radionuclides and stable elements in the two sets of vegetation samples analyzed (vascular and non-vascular species). Such relationships may be directly sought and statistically tested by means of canonical correlation analysis. The comparison between the two variable domains is made on three pairs of canonical variates, this being the number of variables in the smaller set (radionuclides). Based

on the results from profile analysis, and as for PCA, CCA was carried out by separate analyses of the vascular and non-vascular plant samples.

The CCA for vascular plants showed significant correlations between the first two pairs of variates (Appendix 8.7). Therefore the null hypothesis of no relationship between the radionuclide and stable elements is rejected. The first and second variates (V1 and V2) are most highly correlated with Pb^{210} and Ra^{226} respectively (Table 28). The second variate also has a relatively high, negative correlation with uranium. The corresponding sample score ordinations (Figure 10a, b) show high scores on V1 for four species at five localities, all of which have high concentrations of Pb^{210} (0.16 - 0.35 Bq/g). The sample scores on V2 correspond to high values of Ra^{226} (0.13 - 0.36 Bq/g) for all species, except conifers, at Eagle Lake. In contrast, all Mill Site samples have low scores, corresponding to high values for uranium (1.13 - 4.18 μg/g) at this site.

Although the pairs of variates in the respective domains are significantly correlated, there is no general relationship across all samples for any pair of radionuclide and stable element (Appendix 8.7). The low communalities (percentage of variance held in common) for the stable elements and the low redundancies (explained variances) for the canonical variates of both domains support this conclusion. It is therefore not possible to use any of the stable elements studied to predict concentrations of any of the three radionuclides in the vascular vegetation of the geographical area sampled.

Canonical correlation analysis based on the non-vascular plants also results in two significant variates (Appendix 8.8), but this analysis should be interpreted cautiously due to the high number of variables (24) relative to the number of observations (39) (Gittins

1979). The first variate in the radionuclide domain (V1) has high loadings for all three radionuclides (Table 29) and is dominated by the Mill Site (Figure 11). The domination by the Mill Site is due to concentrations of Ra^{226} (0.150 Bq/g) and uranium (17.7 μg/g) in the lichen Cladina mitis at this locality which are 1-2 orders of magnitude larger than at other localities. The three other localities with relatively high scores on the variate, Eagle Lake, Collins Creek and Parks Lake, have high concentrations for Pb^{210} (> 0.55 Bq/g) for their respective species. The second variate (V2) has high negative and positive correlations for Ra^{226} and Pb^{210} respectively, and contrasts the Wollaston Lake localities with the Mill Site, which has the highest negative score due to the very high concentration of Ra^{226} in Cladina mitis.

The canonical variates of the radionuclides resulting from CCA of the non-vascular plants were more successful in explaining variation of the stable elements (redundancy 69%, Appendix 8.8) than in the vascular plant CCA. Nevertheless, the very small redundancies in the stable element domains (total 15%), and the relatively low communalities of both analyses, indicate that none of the stable elements can be used to predict the natural accumulation of any radionuclide by either vascular or non-vascular species. The method did, however, serve to emphasize the Eagle Lake and Mill Site localities as being portions of the data set which lie outside the normal range of variation.

4.2.4 Canonical Variates Analysis (CVA)

Canonical variates analysis is used to test the hypothesis that no differences exist between either species or localities based on their radionuclide and stable element content. Since canonical correlation

analysis demonstrated that both the Mill Site and Eagle Lake localities were outliers with respect to radionuclide concentration in vegetation, those two locations were omitted from CVA to avoid having them dominate the analysis. Five species that were sampled at only one or two localities were also omitted. Since the objective is to seek differences between species, CVA was carried out on the vascular and non-vascular samples simultaneously.

The distribution of significant differences between localities identified by CVA suggests that the Cluff Lake region, with no significant differences between localities within it, is the most homogenous and that the Wollaston Lake region is the most heterogenous (Table 30). Among regions, the Wollaston and Cluff Lake regions are most similar and the Cluff Lake and northernmost Sask./N.W.T. regions have the most differences. These conclusions can be verified by reference to the scatter of the locality scores in the ordination based on the first two canonical variates (Figure 12).

The first three canonical variates are significant (Appendix 8.9). The first separates the northernmost region from the Wollaston and Cluff Lake regions, partly on the basis of high Ra^{226} concentrations in the northern region. The second variate distinguishes the two latter regions; Wollaston on the basis of high uranium concentrations, and Cluff Lake due to high silver levels (Figure 12). The elements associated with all three variates and responsible for separating the regions are summarized in Table 31.

Canonical variates analysis based on localities indicates that there are regional differences in concentration of elements in the plant species sampled. A separate analysis by regions, not reported here, proved the regional centroids (Figure 12) to be significantly different

from one another. Despite the significance of the results, very little variance in the element domain is explained (3.5%) by the analysis by localities, although uranium has the highest proportion of variance accounted for (intraset communality 0.122) over the three significant variates. In contrast, the interset communalities and the redundancies indicate that a much higher proportion of variance (51.8%) is explained by the localities, and, as shown by Figure 12, most of this occurs between the regions. Lead-210 and Ra^{226} make average contributions to the discrimination between localities. Uranium, with an interset communality of 0.776, makes an above-average contribution. The contribution for Ra^{226} is primarily on the first variate in the locality domain, and for Pb^{210} and uranium primarily on the second variate (not tabulated).

The canonical variates analysis of species carried out on the same data set (i.e. excluding the Mill Site and Eagle Lake localities) showed that the species account for more variance than the localities (Appendix 8.10). Nine significant canonical variates were extracted, of which the first four are listed in Appendix 8.10 and summarized in Table 32. The three species-groups (trees, shrubs and lichens) were all significantly different. Differences between species within species-groups were also significant with the exception of those between Labrador tea (Ledum groenlandicum) and crowberry (Empetrum nigrum) in the shrubs, and between Stereocaulon paschale and Cladina mitis and C. stellaris, in the lichens. These non-significant pairs may be the result of the relatively small sample sizes in Empetrum and Stereocaulon.

The ordination of species scores on the first two variates (Figure 13) illustrates the separation of species very well. The first

variate separates the lichens from the vascular plants on the basis of low accumulations of magnesium, copper, manganese, boron, calcium and phosphorous, and high concentrations of Pb^{210} (average 0.38 Bq/g), lead, iron and titanium. These are precisely the elements occupying the two extremes of the profile analysis (Figure 7) and represent nutrients accumulated by vascular plants and crustal elements accumulated by lichens, respectively.

The first variate also distinguishes between some of the vascular species, and this separation is continued on the second variate, with the exception of crowberry (Empetrum nigrum) whose samples overlap those of the other three evergreen shrub species on the two variates illustrated (Figure 13). The sample scores for green alder (Alnus crispa) and jackpine (Pinus banksiana) occupy the two extremes of the second variate. The high scores of A. crispa are associated with high accumulations of copper, cobalt and nickel, and low concentrations of manganese. In contrast, P. banksiana has low concentrations of copper and high concentrations of zinc and aluminum. The lichen species are poorly separated on both of the first two variates.

The interset communalities and the redundancies (Appendix 8.10) show that the species explain a very high proportion of variance (89.6%). The first variate explains the major part of this variance (55.7%). It represents a contrast in mode of element uptake, the lichens primarily accumulating elements distributed in the atmosphere and the vascular plant nutrients from the soil. Lead-210 and uranium have higher than average interset communalities and are therefore important in discriminating between the species.

The two canonical variates analyses demonstrate that a greater proportion of the variance in the data set is associated with the

species than with the localities. The CVA on species separates the lichens from the vascular plants on the basis of their high accumulation of crustal elements (including Pb^{210} and uranium) and essential nutrients repectively, and confirms the results of profile analysis.

Table 9. Summary of weighted mean concentrations of Pb^{210} (Bq/g dry weight) in three plant groups and soil in three sample regions.

Species group	Wollaston Lake	Cluff Lake	N. Sask./ N.W.T.	Group mean
Tree	0.05	0.04	0.08	0.06
Shrub	0.10	0.09	0.06	0.08
Lichen	0.41	0.39	0.28	0.38
Moss	0.55	-	-	0.55
Soil	0.10	0.05	0.21	0.12
Vegetation Mean	0.20	0.17	0.16	

Table 10. Weighted mean concentrations for Pb^{210} (Bq/g dry weight) in northern Saskatchewan and adjacent N.W.T. by region and species. Source of significant differences between regions (ANOVA) indicated by letters.

Species	Wollaston Lake	Cluff Lake	N. Sask. /N.W.T.	ANOVA	Mean
P. banksiana	0.04	-	0.06	n.s.	0.05
P. mariana	0.05	-	0.07	n.s.	0.06
B. neoalaskana	0.09	-	0.10	n.s.	0.10
P. tremuloides	-	0.06	-		0.06
P. banksiana (n)	-	0.06	-		0.06
P. mariana (n)	<0.02	<0.02	-	n.s.	<0.02
				trees	0.06
V. myrtilloides	0.16	0.12	-	n.s.	0.14
L. groenlandicum	0.06	-	0.06	n.s.	0.06
A. crispa	0.12	0.08	0.09	n.s.	0.10
V. vitis-idaea	0.04	0.08	0.05	n.s.	0.07
E. nigrum	0.12	-	0.05	n.s.	0.08
A. uva-ursi	-	0.05	0.05	n.s.	0.05
V. uliginosum	-	-	0.09		0.09
J. communis	-	-	0.06		0.06
				shrubs	0.08
C. rangiferina	A 0.30	-	0.21	*	0.26
C. mitis	0.37	0.35	0.39	n.s.	0.37
C. stellaris	A 0.46	AB 0.43	B 0.24	*	0.38
S. paschale	0.37	-	-		0.37
C. nivalis	0.53	-	-		0.53
				lichens	0.38
P. schreberi	0.55	-	-	moss	0.55
Soil	0.10	0.05	0.21	n.s.	0.12
Vegetation Mean	0.20	0.17	0.16		

n.s. non-significant, * significant at $P<0.05$
(n) needles

Table 11. Weighted mean concentrations for Pb^{210} (Bq/g dry weight) in the Wollaston Lake region by locality and species. Source of significant differences between localities (ANOVA) indicated by letters.

Species	Hidden Bay	Collins Creek	Hungry Island	Cunning Bay	Parks Lake	Labach Lake	Midwest Lake	Minor Bay	ANOVA	Mean
P. banksiana	0.04	-	-	-	-	-	-	-		0.04
P. mariana	B 0.03	A 0.08	-	-	-	-	-	-	*	0.05
B. neoalaskana	-	-	0.09	0.10	0.08	-	-	-	n.s.	0.09
P. mariana (n)	-	-	<0.02	<0.02	<0.02	0.02	<0.02	0.02	n.s.	<0.02
									trees	0.05
V. myrtilloides	AB 0.18	A 0.27	B 0.15	B 0.13	-	B 0.15	B 0.11	B 0.15	**	0.16
L. groenlandicum	0.07	0.08	-	0.05	0.06	0.07	0.06	0.04	n.s.	0.06
A. crispa	-	0.13	0.19	-	0.08	-	-	0.09	n.s.	0.12
V. vitis-idaea	0.08	0.05	0.03	0.06	0.03	0.03	0.04	0.05	n.s.	0.04
E. nigrum	-	-	-	-	-	0.11	0.12	-	n.s.	0.12
									shrubs	0.10
C. rangiferina	-	-	0.33	0.26	0.35	0.32	-	0.25	n.s.	0.30
C. mitis	0.33	0.43	0.42	-	-	-	-	0.29	n.s.	0.37
C. stellaris	0.47	0.50	0.37	0.57	0.55	0.42	0.37	0.42	n.s.	0.46
S. paschale	-	-	-	0.48	0.32	0.30	0.37	-	n.s.	0.37
C. nivalis	-	-	-	-	-	-	0.53	-		0.53
									lichens	0.41
P. schreberi	0.43	0.67	-	-	-	-	-	-	n.s.	0.55
									moss	0.55
Soil	0.03	0.07	0.18	0.09	0.25	0.04	0.04	0.11		0.10
Vegetation Mean	0.24	0.34	0.18	0.19	0.17	0.15	0.18	0.14		

n.s. non-significant, * significant at $P<0.05$, ** $P<0.01$
(n) needles

Table 12. Weighted mean concentration for Pb^{210} (Bq/g dry weight) in the Cluff Lake region by locality and species. Source of significant differences between localities (ANOVA) indicated by letters.

Species	Carswell Lake	South Gate	Carswell North	Jolley Lake	Sandy Lake	Mill Site	ANOVA	Mean
P. tremuloides	0.06	-	-	-	-	-		0.06
P. banksiana (n)	0.04	0.06	0.05	0.03	0.09	0.07	n.s.	0.06
P. mariana (n)	<0.02	-	<0.02	<0.02	-	-	n.s.	<0.02
							trees	0.04
V. myrtilloides	B 0.11	B 0.11	B 0.10	AB 0.12	B 0.10	A 0.18	*	0.12
A. crispa	0.07	0.07	-	-	-	0.10	n.s.	0.08
V. vitis-idaea	0.16	0.06	0.05	0.03	0.04	0.35	n.s.	0.12
A. uva-ursi	-	-	-	-	-	0.05		0.05
							shrubs	0.09
C. mitis	AB 0.37	B 0.27	AB 0.32	AB 0.37	AB 0.33	A 0.47	*	0.35
C. stellaris	-	-	-	-	0.43	-		0.43
							lichens	0.39
Soil	0.04	0.04	0.07	0.04	0.05	0.06	n.s.	0.05
Vegetation Mean	0.17	0.14	0.14	0.16	0.18	0.24		
			Fire Samples					
P. banksiana (n)	-	0.04	0.03	0.03	0.02	0.18	n.s.	0.06
V. myrtilloides	-	B 0.11	B 0.10	B 0.10	B 0.07	A 0.17	**	0.11
Soil	-	0.12	0.08	0.13	0.12	0.04	n.s.	0.10

n.s. non-significant, * $P<0.05$, ** $P<0.01$
(n) needles

Table 13. Weighted mean concentration for Pb^{210} (Bq/g dry weight) in the northernmost Saskatchewan and N.W.T. region by locality and species. Source of significant differences between localities (ANOVA) indicated by letters.

Species	Uranium City	Eagle Lake	Tazin River	Ena Lake	McInnes Lake	Dunvegan Lake	ANOVA	Mean
P. banksiana	0.03	0.05	0.08	0.09	-	-	n.s.	0.06
P. mariana	0.07	0.09	0.06	0.06	0.04	0.06	n.s.	0.07
B. neoalaskana	0.05	0.21	0.07	0.11	0.07	0.10	n.s.	0.10
							trees	0.08
L. groenlandicum	0.05	0.06	0.07	0.05	0.03	0.07	n.s.	0.06
A. crispa	B 0.06	A 0.16	B 0.05	B 0.07	-	-	**	0.09
V. vitis-idaea	0.04	0.04	0.04	0.07	0.04	0.05	n.s.	0.05
E. nigrum	-	-	-	-	0.03	0.07	n.s.	0.05
A. uva-ursi	0.05	-	-	-	-	-		0.05
V. uliginosum	-	-	-	-	-	0.09		0.09
J. communis	0.06	-	-	-	-	-		0.06
							shrubs	0.06
C. rangiferina	-	-	-	-	0.22	0.21	n.s.	0.21
C. mitis	0.32	0.62	0.32	0.32	-	-	n.s.	0.39
C. stellaris	-	-	-	-	0.25	0.23	n.s.	0.24
							lichens	0.28
Soil	0.06	1.05	0.04	0.04	0.04	0.04	n.s.	0.21
Vegetation Mean	0.14	0.27	0.15	0.16	0.11	0.12		

n.s. non-significant, significant at ** $P<0.01$

Table 14. Summary of weighted mean concentrations of Ra^{226} (Bq/g dry weight) in three plant groups and soil in three sample regions.

Species group	Wollaston Lake	Cluff Lake	N. Sask./ N.W.T.	Group mean
Tree	0.004	0.005	0.024	0.012
Shrub	0.014	0.017	0.047	0.028
Lichen	0.009	0.021	0.012	0.011
Moss	0.008	-	-	0.008
Soil	0.043	0.014	0.387	0.148
Vegetation Mean	0.009	0.016	0.031	

Table 15. Weighted mean concentrations for Ra^{226} (Bq/g dry weight x 100) in three regions of northern Saskatchewan and adjacent N.W.T. by region and species.

Species	Wollaston Lake	Cluff Lake	N. Sask. /N.W.T.	ANOVA	Mean
P. banksiana	0.19	-	-		0.19
P. mariana	0.16	-	2.07	n.s.	1.12
B. neoalaskana	0.75	-	5.79	n.s.	3.27
P. tremuloides	-	0.70	-		0.70
P. banksiana (n)	-	0.54	0.52	n.s.	0.53
P. mariana (n)	0.22	0.16	0.63	n.s.	0.34
				trees	1.21
V. myrtilloides	1.60	1.46	-	n.s.	1.53
L. groenlandicum	1.87	-	7.36	n.s.	4.61
A. crispa	1.10	1.48	5.85	n.s.	2.81
V. vitis-idaea	1.25	1.37	3.22	n.s.	1.95
E. nigrum	1.07	-	1.78	n.s.	1.43
A. uva-ursi	-	2.39	11.17	n.s.	6.78
V. uliginosum	-	-	1.25		1.25
J. communis	-	-	1.91		1.91
				shrubs	2.78
C. rangiferina	0.86	-	0.94	n.s.	0.90
C. mitis	0.72	3.10	1.49	n.s.	1.77
C. stellaris	0.75	1.02	1.14	n.s.	0.97
S. paschale	1.19	-	-		1.19
C. nivalis	0.88	-	-		0.88
				lichens	1.14
P. schreberi	0.77	-	-		0.77
Soil	4.29	1.44	38.72	n.s.	14.82
Vegetation Mean	0.89	1.64	3.05		

n.s. non-significant ($p > 0.05$)
(n) needles

Table 16. Weighted mean concentrations for Ra^{226} (Bq/g dry weight x 100) in the Wollaston Lake region by locality and species. Source of significant differences between localities (ANOVA) indicated by letters.

Species	Hidden Bay	Collins Creek	Hungry Island	Cunning Bay	Parks Lake	Labach Lake	Midwest Lake	Minor Bay	ANOVA	Mean
P. banksiana	0.19	-	-	-	-	-	-	-		0.19
P. mariana	0.17	0.16	-	-	-	-	-	-	n.s.	0.16
B. neoalaskana	-	-	0.08	1.18	0.99	-	-	-	n.s.	0.75
P. mariana (n)	-	-	AB 0.17	A 0.29	AB 0.24	AB 0.24	AB 0.26	B 0.10	*	0.22
									trees	0.38
V. myrtilloides	1.09	2.41	2.23	1.35	-	1.62	1.31	1.18	n.s.	1.60
L. groenlandicum	1.35	1.81	-	2.47	2.28	1.99	1.94	1.25	n.s.	1.87
A. crispa	-	B 0.74	A 1.74	-	-	-	-	B 0.84	**	1.10
V. vitis-idaea	B 0.52	AB 1.16	A 1.85	AB 1.22	AB 1.60	A 1.63	AB 1.05	AB 0.97	*	1.25
E. nigrum	-	-	-	-	-	1.01	1.14	-	n.s.	1.07
									shrubs	1.38
C. rangiferina	-	-	AB 0.61	AB 0.66	A 1.61	AB 1.07	-	B 0.35	*	0.86
C. mitis	0.56	0.96	0.79	-	-	-	-	0.57	n.s.	0.72
C. stellaris	C 0.43	C 0.44	B 1.07	BC 0.55	A 1.77	BC 0.68	BC 0.65	C 0.44	***	0.75
S. paschale	-	-	-	0.44	3.53	0.45	0.33	-	n.s.	1.19
C. nivalis	-	-	-	-	-	-	0.88	-		0.88
									lichens	0.88
P. schreberi	0.59	0.95	-	-	-	-	-	-	n.s.	0.77
Soil	AB 3.50	A 6.50	AB 5.67	B 3.00	AB 5.33	B 2.33	B 3.00	AB 5.00	***	4.29
Vegetation Mean	0.56	0.84	0.96	0.99	1.62	0.84	0.75	0.54		

n.s. non-significant, * significant at $P<0.05$, ** $P<0.01$, *** $P<0.001$
(n) needles

Table 17. Weighted mean concentrations for Ra^{226} (Bq/g dry weight x 100) in the Cluff Lake region by locality and species. Source of significant differences between localities (ANOVA) indicated by letters.

Species	Carswell Lake	South Gate	Carswell North	Jolley Lake	Sandy Lake	Mill Site	ANOVA	Mean
P. tremuloides	0.70	-	-	-	-	-		0.70
P. banksiana (n)	B 0.17	B 0.26	B 0.20	B 0.14	B 0.30	A 2.19	***	0.54
P. mariana (n)	0.14	-	0.18	0.16	-	-	n.s.	0.16
							trees	0.47
V. myrtilloides	B 0.93	B 0.83	B 0.86	B 0.85	B 0.87	A 4.43	***	1.46
A. crispa	AB 1.04	B 0.75	-	-	-	A 2.65	*	1.48
V. vitis-idaea	B 0.63	B 1.26	B 1.08	B 0.80	B 0.70	A 3.74	***	1.37
A. uva-ursi	-	-	-	-	-	2.39		2.39
							shrubs	1.67
C. mitis	B 0.63	B 0.40	B 0.25	B 1.09	B 1.40	A14.86	***	3.10
C. stellaris	-	-	-	-	1.02	-		1.02
							lichens	2.06
Soil	1.67	1.00	2.00	1.33	1.67	1.00	n.s.	1.44
Vegetation Mean	0.61	0.53	0.47	0.69	0.76	6.78		
			Fire Samples					
P. banksiana (n)	-	B 0.17	B 0.21	B 0.09	B 0.14	A 2.09	***	0.54
V. myrtilloides	-	B 0.92	B 1.77	B 1.80	B 1.19	A 4.74	***	2.09
Soil	-	1.00	1.67	0.83	1.33	1.00	n.s.	1.17

n.s. non-significant, * significant at $P<0.05$, ** $P<0.01$, *** $P<0.001$
(n) needles

Table 18. Weighted mean concentrations for Ra^{226} (Bq/g dry weight x 100) in northernmost Saskatchewan and N.W.T. region by locality and species. Source of significant differences between localities (ANOVA) indicated by letters.

Species	Uranium City	Eagle Lake	Tazin River	Ena Lake	McInnes Lake	Dunvegan Lake	ANOVA	Mean
P. mariana	1.01	4.83	-	-	0.36	-	n.s.	2.07
B. neoalaskana	AB 3.73	A 25.47	B 1.05	B 0.96	B 2.16	B 1.41	*	5.79
P. banksiana (n)	0.43	1.04	0.23	0.36	-	-	n.s.	0.52
P. mariana (n)	A 1.92	B 0.67	C 0.24	C 0.18	-	C 0.18	***	0.63
							trees	2.42
L. groenlandicum	2.03	35.88	1.57	0.98	2.48	1.20	n.s.	7.36
A. crispa	2.20	20.11	0.61	0.50	-	-	n.s.	5.85
V. vitis-idaea	1.24	12.90	1.06	1.09	2.12	0.93	n.s.	3.22
E. nigrum	-	-	-	-	A 2.71	B 0.85	*	1.78
A. uva-ursi	11.17	-	-	-	-	-		11.17
V. uliginosum	-	-	-	-	-	1.25		1.25
J. communis	1.91	-	-	-	-	-		1.91
							shrubs	4.65
C. rangiferina	-	-	-	-	1.01	0.87	n.s.	0.94
C. mitis	1.63	3.19	0.74	0.38	-	-	n.s.	1.49
C. stellaris	-	-	-	-	A 1.58	B 0.69	**	1.14
							lichens	1.19
Soil	11.00	210.67	2.00	2.00	4.00	2.67	n.s.	38.72
Vegetation Mean	2.39	12.05	0.77	0.58	1.66	0.88		

n.s. non-significant, * significant at $P<0.05$, ** $P<0.01$, *** $P<0.001$
(n) needles

Table 19. Summary of weighted mean concentrations of uranium in three plant groups and soil in three sample regions (μg/g dry weight).

Species group	Wollaston Lake	Cluff Lake	N. Sask./ N.W.T.	Group mean
Tree	0.245	0.184	0.019	0.120
Shrub	0.112	0.711	0.022	0.199
Lichen	1.136	1.802	0.060	0.847
Moss	3.071	-	-	3.071
Soil	1.417	0.428	56.711	19.519
Vegetation Mean	0.672	1.347	0.048	

Table 20. Weighted mean concentrations of uranium (µg/g dry weight) in three regions of northern Saskatchewan and adjacent N.W.T. by region and species. Source of significant differences between localities (ANOVA) indicated by letters.

Species	Wollaston Lake	Cluff Lake	N. Sask. /N.W.T.	ANOVA	Mean
P. banksiana	0.567	-	-		0.567
P. mariana	A 0.174	-	B 0.015	*	0.094
B. neoalaskana	0.112	-	0.027	n.s.	0.070
P. tremuloides	-	0.011	-		0.011
P. banksiana (n)	-	0.536	0.022	n.s.	0.279
P. mariana (n)	0.019	0.006	0.005	n.s.	0.010
				trees	0.120
V. myrtilloides	0.203	0.726	-	n.s.	0.465
L. groenlandicum	0.106	-	0.017	n.s.	0.061
A. crispa	0.057	0.686	0.025	n.s.	0.257
V. vitis-idaea	0.121	0.297	0.022	n.s.	0.147
E. nigrum	0.074	-	0.008	n.s.	0.041
A. uva-ursi	-	A 1.134	B 0.058	**	0.596
V. uliginosum	-	-	0.006		0.006
J. communis	-	-	0.021		0.021
				shrubs	0.199
C. rangiferina	1.107	-	0.013	n.s.	0.560
C. mitis	1.708	3.111	0.153	n.s.	1.657
C. stellaris	1.527	0.493	0.013	n.s.	0.678
S. paschale	0.883	-	-		0.883
C. nivalis	0.456	-	-		0.456
				lichens	0.847
P. schreberi	3.071	-	-		3.071
Soil	AB 1.417	B 0.428	A 56.711	*	19.519
Vegetation Mean	0.672	1.347	0.048		

n.s. non-significant, * significant at $P<0.05$, ** $P<0.01$
(n) needles

Table 21. Weighted mean concentrations of uranium (µg/g dry weight) in the Wollaston Lake region by locality and species. Source of significant differences between localities (ANOVA) indicated by letters.

Species	Hidden Bay	Collins Creek	Hungry Island	Cunning Bay	Parks Lake	Labach Lake	Midwest Lake	Minor Bay	ANOVA	Mean
P. banksiana	0.567	-	-	-	-	-	-	-		0.567
P. mariana	0.127	0.221	-	-	-	-	-	-	n.s.	0.174
B. neoalaskana	-	-	0.056	0.019	0.260	-	-	-	n.s.	0.112
P. mariana (n)	-	-	B 0.016	B 0.006	A 0.070	B 0.005	B 0.009	B 0.006	***	0.019
V. myrtilloides	A 0.512	A 0.611	B 0.121	B 0.036	-	B 0.018	B 0.082	B 0.044	trees	0.245
L. groenlandicum	AB 0.191	B 0.157	-	C 0.017	A 0.300	C 0.013	C 0.044	C 0.018	***	0.203
V. crispa	-	A 0.127	BC 0.038	-	B 0.067	-	-	C <0.003	***	0.106
V. vitis-idaea	A 0.219	A 0.290	B 0.052	B 0.021	A 0.288	B 0.009	B 0.070	B 0.017	***	0.121
E. nigrum	-	-	-	-	-	B 0.024	A 0.124	-	***	0.074
C. rangiferina	-	-	B 0.675	C 0.243	A 4.244	C 0.140	-	C 0.233	***	1.107
C. mitis	A 2.522	A 3.390	B 0.688	-	-	-	-	C 0.230	***	1.708
C. stellaris	B 2.854	B 2.410	C 0.704	CD 0.284	A 5.237	D 0.136	CD 0.364	D 0.225	***	1.527
S. paschale	-	-	-	B 0.237	A 2.960	B 0.105	B 0.232	-	***	0.883
C. nivalis	-	-	-	-	-	-	0.456	-		0.456
P. schreberi	B 2.534	A 3.609	-	-	-	-	-	-	lichens	1.136
Soil	D 0.867	ABC 1.667	ABC 1.500	D 0.867	A 2.067	CD 1.167	BC 1.367	AB 1.833	*	3.071
Vegetation Mean	1.469	1.757	0.265	0.097	1.510	0.049	0.147	0.085	***	1.417

n.s. non-significant, * significant at P<0.05, ** P<0.01, *** P<0.001
(n) needles

Table 22. Weighted mean concentrations of uranium (µg/g dry weight) in the Cluff Lake region by locality and species. Source of significant differences between localities (ANOVA) indicated by letters.

Species	Carswell Lake	South Gate	Carswell North	Jolley Lake	Sandy Lake	Mill Site	ANOVA	Mean
P. tremuloides	0.011	-	-	-	-	-		0.011
P. banksiana (n)	B 0.027	B 0.011	B 0.008	B 0.021	B 0.039	A 3.110	***	0.536
P. mariana (n)	0.005	-	0.006	0.007	-	-	n.s.	0.006
							trees	0.184
V. myrtilloides	B 0.031	B 0.031	B 0.014	B 0.043	B 0.056	A 4.181	***	0.726
A. crispa	B 0.031	B 0.008	-	-	-	A 2.021	***	0.686
V. vitis-idaea	BC 0.023	BC 0.015	C 0.010	BC 0.012	B 0.030	A 1.694	***	0.297
A. uva-ursi	-	-	-	-	-	1.134		1.134
							shrubs	0.711
C. mitis	BC 0.161	BC 0.090	C 0.066	BC 0.168	B 0.509	A17.674	***	3.111
C. stellaris	-	-	-	-	0.493	-		0.493
							lichens	1.802
Soil	0.400	0.367	0.467	0.367	0.467	0.500	n.s.	0.428
Vegetation Mean	0.068	0.039	0.028	0.070	0.194	7.680		
			Fire Samples					
P. banksiana (n)	-	B 0.012	B 0.006	B 0.009	B 0.010	A 2.905	***	0.588
V. myrtilloides	-	B 0.023	B 0.009	B 0.021	B 0.008	A 3.315	***	0.675
Soil	-	0.333	0.333	0.333	0.367	0.433	n.s.	0.360

n.s. non-significant, *** significant at $P<0.001$
(n) needles

Table 23. Weighted mean concentrations of uranium (µg/g dry weight) in the northernmost Saskatchewan and N.W.T. region by locality and species. Source of significant differences between localities (ANOVA) indicated by letters.

Species	Uranium City	Eagle Lake	Tazin River	Ena Lake	McInnes Lake	Dunvegan Lake	ANOVA	Mean
P. mariana	AB 0.015	A 0.024	-	-	B 0.005	-	**	0.015
B. neoalaskana	0.069	0.064	0.006	0.009	0.007	0.008	n.s.	0.027
P. banksiana (n)	0.017	0.034	0.005	0.033	-	-	n.s.	0.022
P. mariana (n)	0.010	0.004	0.007	0.003	-	0.003	n.s.	0.005
							trees	0.019
L. groenlandicum	A 0.035	A 0.046	B 0.003	B 0.008	B 0.004	B 0.005	***	0.017
A. crispa	AB 0.030	A 0.058	B 0.005	B 0.005	-	-	**	0.025
V. vitis-idaea	0.039	0.065	0.006	0.009	0.007	0.007	n.s.	0.022
E. nigrum	-	-	-	-	0.008	0.008	n.s.	0.008
A. uva-ursi	0.058	-	-	-	-	-		0.058
V. uliginosum	-	-	-	-	-	0.006		0.006
J. communis	0.021	-	-	-	-	-		0.021
							shrubs	0.022
C. rangiferina	-	-	-	-	B 0.010	A 0.016	*	0.013
C. mitis	B 0.144	A 0.409	C 0.024	C 0.033	-	-	***	0.153
C. stellaris	-	-	-	-	B 0.010	A 0.016	*	0.013
							lichens	0.060
Soil	9.000	324.700	1.033	0.900	3.567	1.067	n.s.	56.711
Vegetation Mean	0.071	0.168	0.012	0.019	0.007	0.009		

n.s. non-significant, * significant at $P<0.05$, ** $P<0.01$, *** $P<0.001$
(n) needles

Table 24. Comparison of five fire and non-fire sites in the Cluff Lake region. Average concentrations for localities excluding the Mill Site locality. Probability indicates results of pairwise t-tests including the Mill Site.

	Fire	Non-fire	Probability
Vaccinium myrtilloides			
Pb^{210} (Bq/g)	0.09	0.11	0.099
Ra^{226} (Bq/g)	0.0142	0.0085	0.042
Uranium (μg/g)	0.015	0.036	0.190
Pinus banksiana			
Pb^{210} (Bq/g)	0.03	0.06	0.979
Ra^{226} (Bq/g)	0.0015	0.0022	0.052
Uranium (μg/g)	0.009	0.020	0.134
Soil			
Pb^{210} (Bq/g)	0.11	0.05	0.092
Ra^{226} (Bq/g)	0.0120	0.0150	0.080
Uranium (μg/g)	0.341	0.417	0.019

Table 25. Radionuclide concentrations in groundwater samples in three regions of northern Saskatchewan and adjacent N.W.T.

	Wollaston Lake		Cluff	N. Sask./N.W.T.		
	Hidden Bay	Midwest Lake	Mill Site*	Uranium City	Eagle Lake	Ena Lake
Pb^{210} Bq/l	<0.02	<0.02	<0.02	<0.02	0.05	<0.02
Ra^{226} Bq/l	<0.005	0.005	0.03-0.08	0.100	0.020	0.005
Uranium µg/l	<0.05	<0.5	1.8-9.9	18.0±1.0	2.6±1.0	<0.5

*Ranges of the average of four test wells sampled 1983-85, adjacent to the tailings storage area.

Table 26. Summary of principal components analysis of vascular plant samples after rotation. Signs indicate degree of correlation with components.

Component	Association with components		
	Elements	Species	Locality/Region
1	++ Vanadium, boron + silver, titanium, chromium, iron, manganese	++ V. myrtilloides	Cluff Lake region
2	+ Nickel, copper, cobalt	+ A. crispa	Eagle Lake
	+ Ra^{226}	+ L. groenlandicum B. neoalaskana	Eagle Lake
	+ Pb^{210}	+ V. myrtilloides	all localities
	- copper, - Ra^{226}	- conifers	Collins Creek
3	+ Zinc	+ B. neoalaskana	all localities
	- Potassium	- B. neoalaskana - P. banksiana	all localities
	+ Cadmium	++ V. uliginosum + B. neoalaskana	Dunvegan Lake all localities
4	+ Beryllium, Phosphorus	+ A. crispa	Collins Creek, Minor Bay
5	+ Barium	+ three species	four sites
	- Barium	- two species	three sites
6	+ Uranium	+ All	Mill site

Table 27. Summary of principal components analysis of non-vascular plant samples after rotation. Signs indicate degree of correlation with components.

Component	Association with components		
	Element	Species	Locality/Region
1	++ iron, titanium, aluminum, beryllium, vanadium, cobalt + nickel, sodium	-- *Cladina* spp.	N.W.T. and N. Sask. except Uranium City and Eagle Lake
2	+ potassium, phosphorous, magnesium, calcium, copper, manganese, boron	+ moss	Hidden Bay Collins Creek
3	+ Ra^{226}, silver, uranium	+ *C. mitis*	Mill site
4	+ cadmium + lead	+ *Stereocaulon* - *C. mitis*	Labach Lake Carswell Lake, South Gate
5	+ Pb^{210}	+ all species	Collins Creek

Table 28. Summary of canonical correlation analysis comparing radionuclide and stable element concentrations in vascular plant samples. Signs indicate degree of correlation with variates.

Canonical Variate	Association with canonical variates		
	Elements	Species	Locality/Region
V1	++ Pb^{210}	+ V. vitis-idaea	Mill site
		V. myrtilloides	Collins Creek
			Hidden Bay
		B. neoalaskana	Eagle Lake
		A. crispa	Hungry Island
			Eagle Lake
V2	++ Ra^{226}	+ All species, except conifers	Eagle Lake
	- U	+ All species	Mill site
W1	+ Fe	+ V. myrtilloides	Wollaston
		+ V. vitis-idaea	Mill site
	+ Cu	+ A. crispa	Eagle Lake
W2	+ Co	+ All species	Eagle Lake
		++ A. crispa	
	- Cr	- All species	N. Sask./NWT
		+ P. banksiana	Mill site
		V. vitis-idaea	

Table 29. Summary of canonical correlation analysis comparing radionuclide and stable element concentrations in non-vascular plant samples. Signs indicate degree of correlation with variates.

Canonical Variate	Association with canonical variates		
	Elements	Species	Locality/Region
V1	+ Ra^{226}, Uranium	+ C. mitis	Mill site Eagle Lake
	+ Pb^{210}	P. schreberi C. stellaris	Collins Creek Parks Lake
V2	- Ra^{226} + Pb^{210}		- Mill Site + Wollaston, - N. Sask./NWT
W1	+ lead, silver, aluminum	+ C. mitis	Mill site
	+ nickel + cobalt	+ P. schreberi + C. mitis	Collins Creek Eagle Lake
W2	- Silver + Cadmium, chromium	- C. mitis	Mill Site + Wollaston, - N. Sask./NWT

Table 30. Canonical variates analysis by localities. Percentage number of significant differences ($P < 0.05$) within and between pairs of localities (in the three sample regions) based on Mahalanobis distances. Number of localities within region in brackets.

	Regions		
	1	2	3
1. Wollaston Lake (8)	61%	60%	82%
2. Cluff Lake (5)*		0%	100%
3. N. Sask./N.W.T. (5)**			40%

* Mill Site not included

** Eagle Lake not included

Table 31. Summary of canonical variates analysis by localities.

Signs indicate degree of correlation with the variates.

Canonical Variate	Association with Canonical Variates Element	Locality/Region
CAN 1	++ chromium, vanadium aluminum	+ Wollaston, Cluff regions
	- Ra^{226}	+ N. Sask/N.W.T.
CAN 2	+ uranium	+ Wollaston
	- silver	- Cluff
CAN 3	+ uranium	+ Hidden Bay, Collins Creek, Parks Lake localities
		- Remaining Wollaston localities

Table 32. Summary of canonical variates analysis by species. Signs indicate degree of correlation with the variates.

Canonical Variate	Association with canonical variates	
	Element	Species
CAN 1	+++ magnesium, copper,	+ vascular plants - lichens
	++ manganese, boron, calcium,	
	+ phosphorus	
	-- Pb^{210}	
	- lead, iron, titanium	
CAN 2	+ copper, cobalt nickel,	+ Alnus crispa
	- manganese	
	+ copper,	- Pinus banksiana
	- zinc, aluminum	
CAN 3	- zinc, cadmium,	- Betula neoalaskana
	- aluminum	
	+ aluminum	+ Vaccinium spp.
CAN 4	+ copper, cadmium, Pb^{210}, titanium	+ B. neoalaskana at Uranium City - Picea mariana
	+ Pb^{210}	+ B. neoalaskana, V. myrtilloides

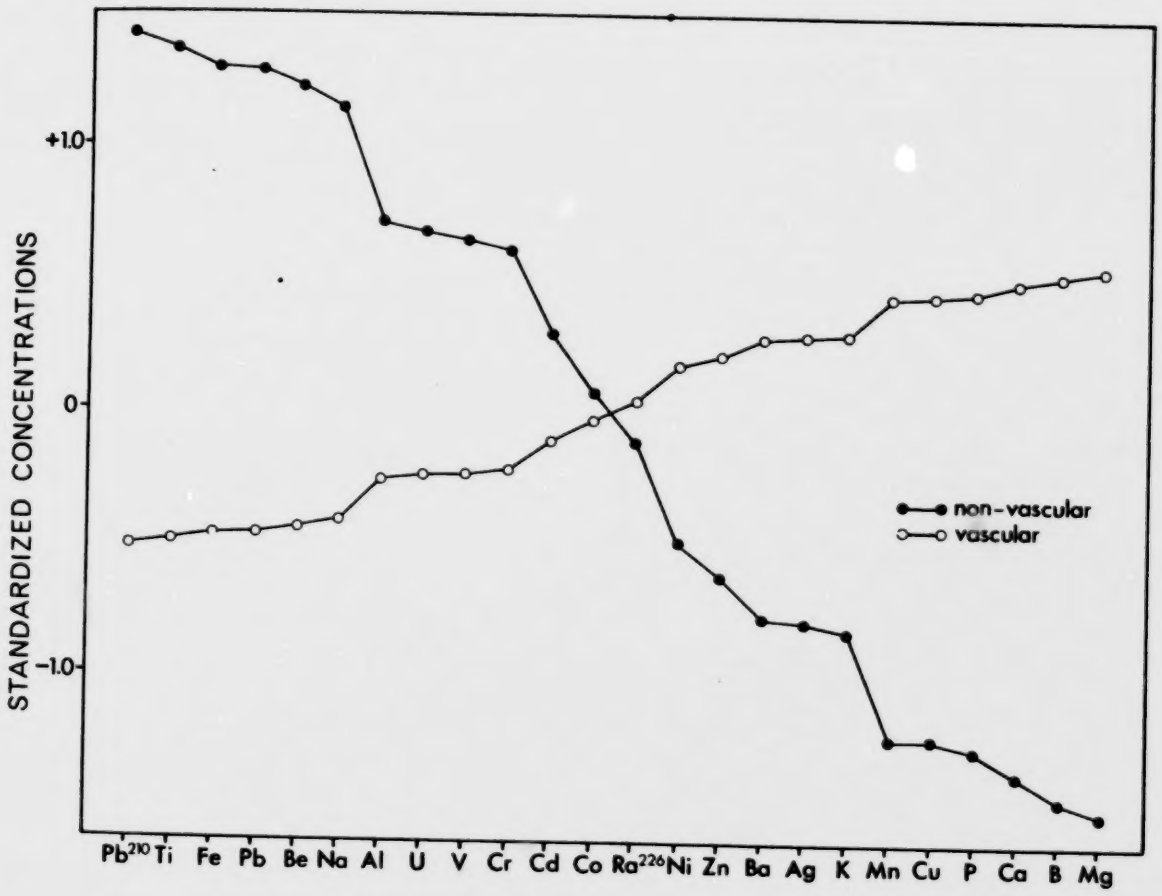


Figure 7. Profile analysis contrasting vascular (trees and shrubs) and non-vascular plants (lichens and mosses). The null hypothesis of parallel profiles is rejected, P = <0.0001. The intersecting profiles imply different uptake mechanisms for the set of radionuclides and stable elements in the two plant groups.

Figure 8. Principal components analysis of vascular plant samples. Sample scores on first two components, labelled by a) species and b) locality. Six samples are missing due to overlap. Signs indicate the degree of correlation of elements and radionuclides with the respective components.

a) Species symbols

A	Vaccinium myrtilloides	Canada Blueberry
B	Pinus banksiana	Jackpine
C	Ledum groenlandicum	Labrador Tea
D	Alnus crispa	Green Alder
E	Vaccinium vitis-idaea	Cranberry
F	Picea mariana	Black Spruce
K	Betula neoalaskana	Paper Birch
M	Empetrum nigrum	Crowberry
0	Populus tremuloides	Trembling Aspen
P	Arctostaphyllos uva-ursi	Bearberry
T	Vaccinium uliginosum	Alpine Bilberry
U	Juniperus communis	Common Juniper
W	Pinus banksiana (needles)	
X	Picea mariana (needles)	

b) locality symbols

Wollaston Bay region

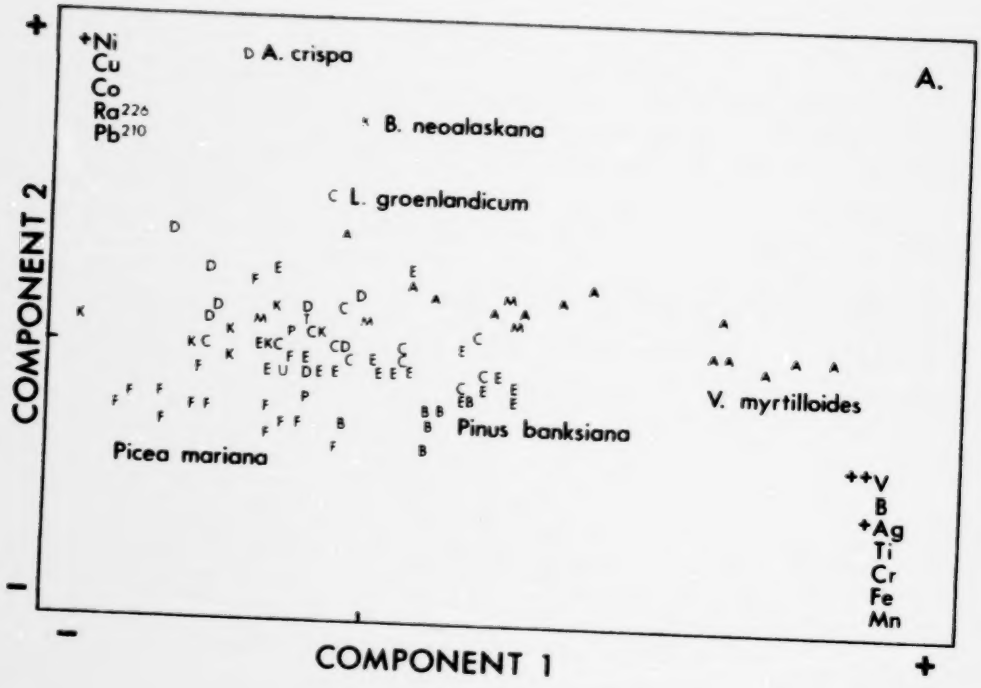
A	Hidden Bay
B	Collins Creek
E	Hungry Island
F	Cunning Bay
G	Parks Lake
H	Labach Lake
I	Midwest Lake
J	Minor Bay

Cluff Lake region

K	Carswell Lake
L	South Gate
M	Carswell North
N	Jolley Lake
O	Sandy Lake
P	Mill Site

N. Sask./N.W.T.

Q	Uranium City
R	Eagle Lake
S	Tazin River
T	Ena Lake
U	McInnes Lake
V	Dunvegan Lake


+Ni
Cu
Co
Ra226
Pb210
D A. crispa
B. neoalaskana
L. groenlandicum
A.
Picea mariana
Pinus banksiana
V. myrtilloides
++V
B
+Ag
Ti
Cr
Fe
Mn
COMPONENT 2
COMPONENT 1

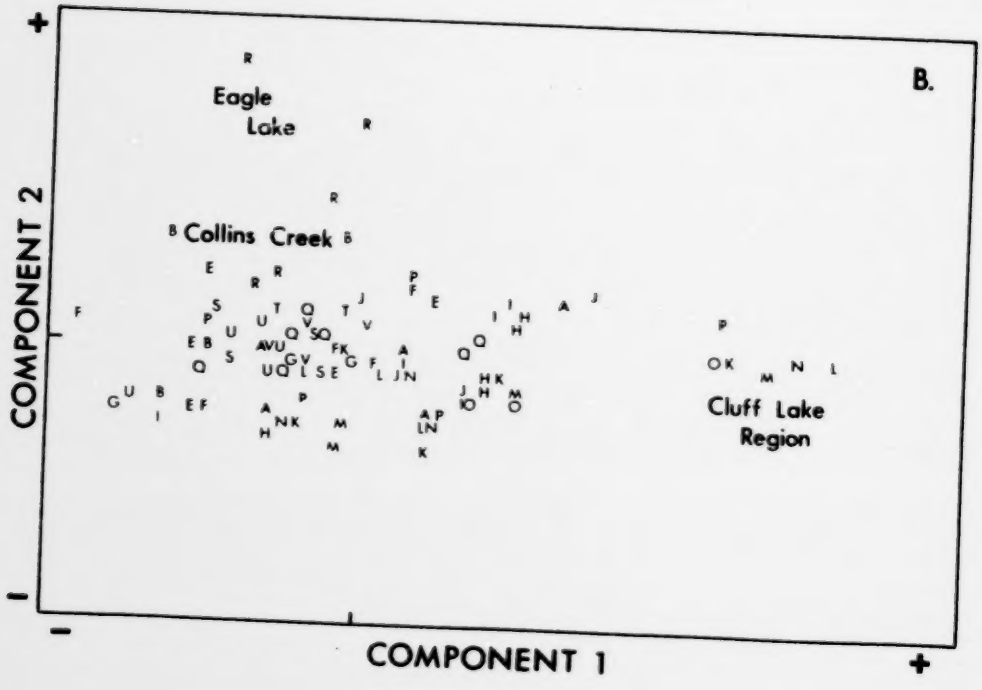

B.
Eagle
Lake
B Collins Creek B
Cluff Lake
Region
COMPONENT 2
COMPONENT 1

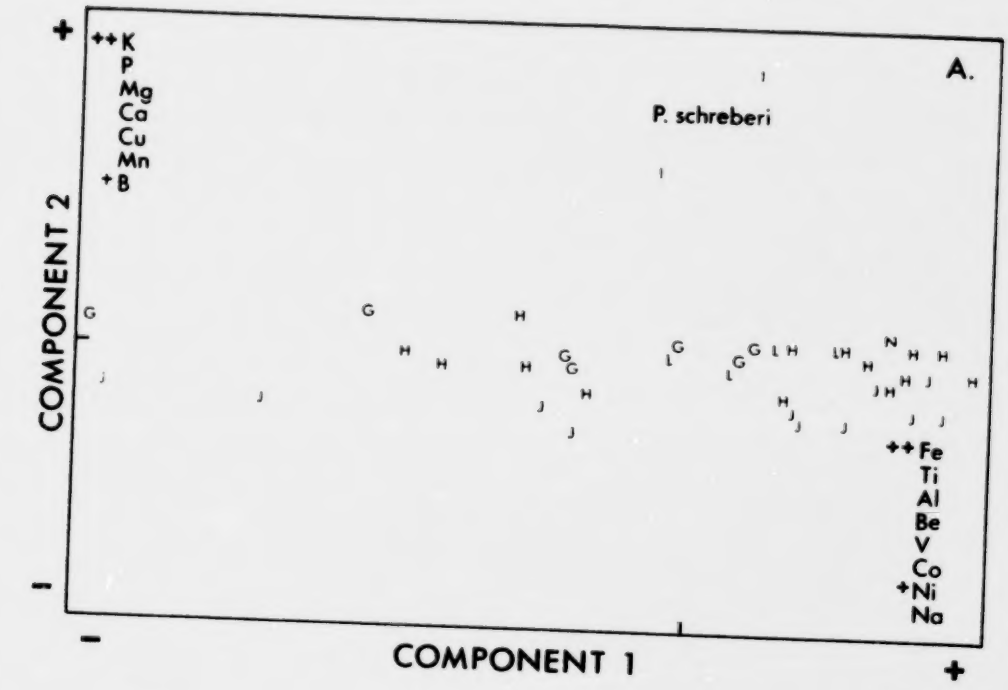
Figure 9. Principal components analysis of non-vascular plant samples. Sample scores on first two components, labelled by a) species and b) regions. Signs indicate the degree of correlation of elements and radionuclides with the respective components.

a) Species symbols

G	Cladina rangiferina	Caribou lichen
H	Cladina mitis	Caribou lichen
I	Pleurozium schreberi	Feather moss
J	Cladina stellaris	Caribou lichen
L	Stereocaulon paschale	Lichen
N	Cetraria nivalis	Lichen

b) region symbols

1. Wollaston Bay
2. Cluff Lake
3. N. Sask./N.W.T.


A.
++K
P
Mg
Ca
Cu
Mn
+B
P. schreberi
++Fe
Ti
Al
Be
V
Co
+Ni
Na
COMPONENT 2
COMPONENT 1
+
-

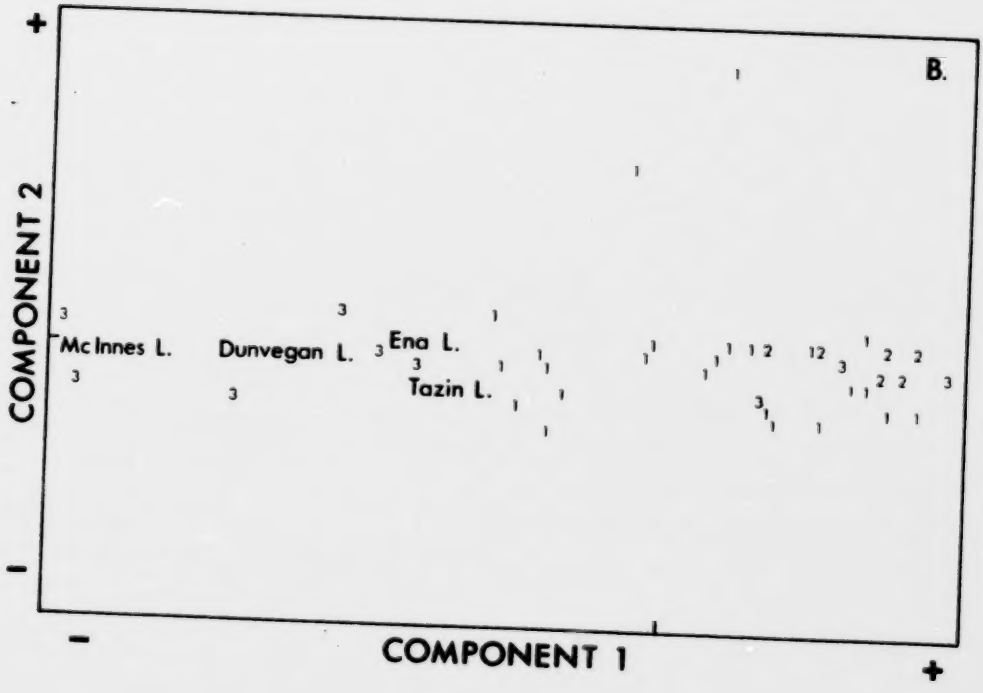

B.
McInnes L.
Dunvegan L.
Ena L.
Tazin L.
COMPONENT 2
COMPONENT 1
+
-

Figure 10. Canonical correlation analysis of vascular plant samples. Sample scores on first two canonical variates in the radionuclide domain, labelled by a) species, b) locality. Twenty two observations are missing due to overlap. Signs indicate the degree of correlation of elements and radionuclides with the respective components.

a) Species symbols

A	Vaccinium myrtilloides	Canada Blueberry
B	Pinus banksiana	Jackpine
C	Ledum groenlandicum	Labrador Tea
D	Alnus crispa	Green Alder
E	Vaccinium vitis-idaea	Cranberry
F	Picea mariana	Black Spruce
K	Betula neoalaskana	Paper Birch
M	Empetrum nigrum	Crowberry
N	Populus tremuloides	Trembling Aspen
0	Arctostaphyllos uva-ursi	Bearberry
T	Vaccinium uliginosum	Alpine Bilberry
U	Juniperus communis	Common Juniper
W	Pinus banksiana (needles)	
X	Picea mariana (needles)	

b) locality symbols

Wollaston Bay region

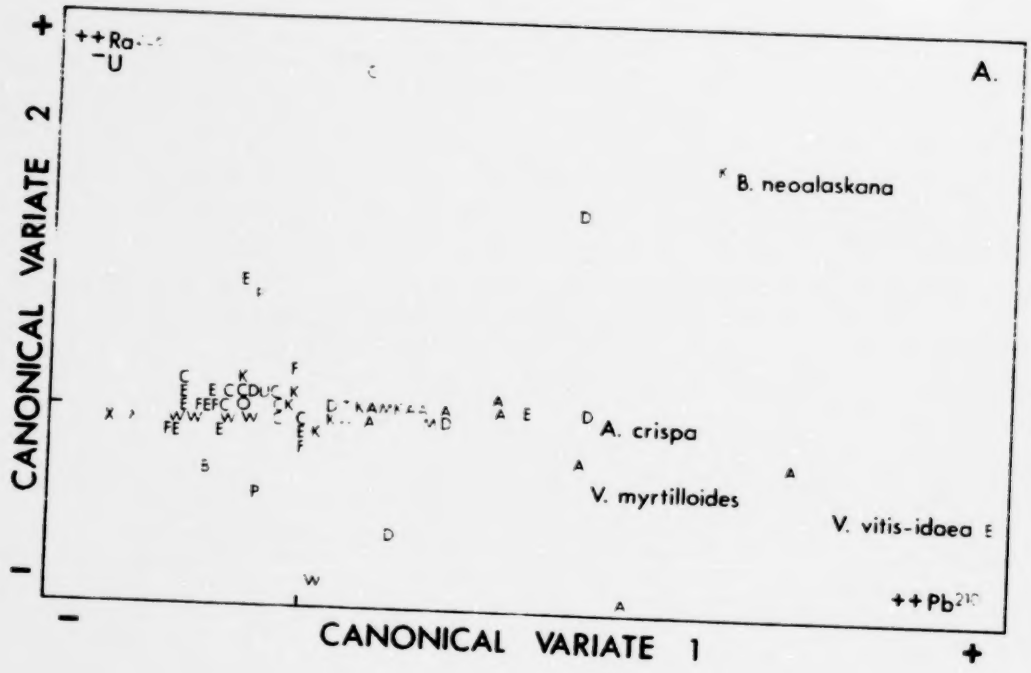
A	Hidden Bay
B	Collins Creek
E	Hungry Island
F	Cunning Bay
G	Parks Lake
H	Labach Lake
I	Midwest Lake
J	Minor Bay

Cluff Lake region

K	Carswell Lake
L	South Gate
M	Carswell North
N	Jolley Lake
O	Sandy Lake
P	Mill Site

N. Sask./N.W.T.

Q	Uranium City
R	Eagle Lake
S	Tazin River
T	Ena Lake
U	McInnes Lake
V	Dunvegan Lake


A.
++Ra
−U
B. neoalaskana
A. crispa
V. myrtilloides
V. vitis-idaea
++Pb210
CANONICAL VARIATE 2
CANONICAL VARIATE 1
+
−

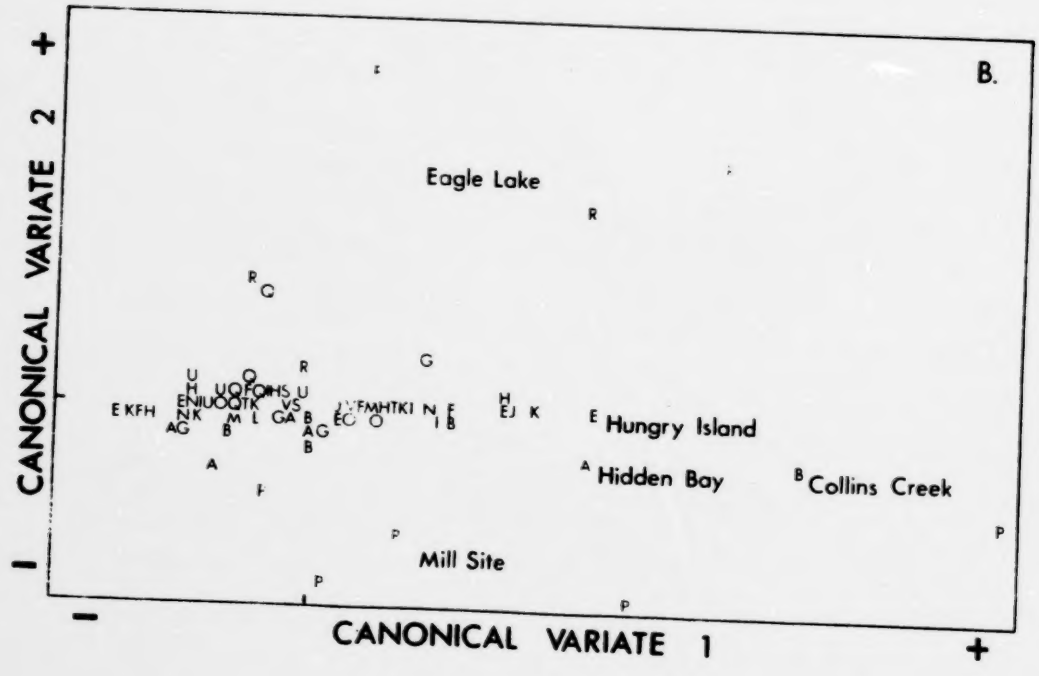

B.
Eagle Lake
Hungry Island
Hidden Bay
Collins Creek
Mill Site
CANONICAL VARIATE 2
CANONICAL VARIATE 1
+
−

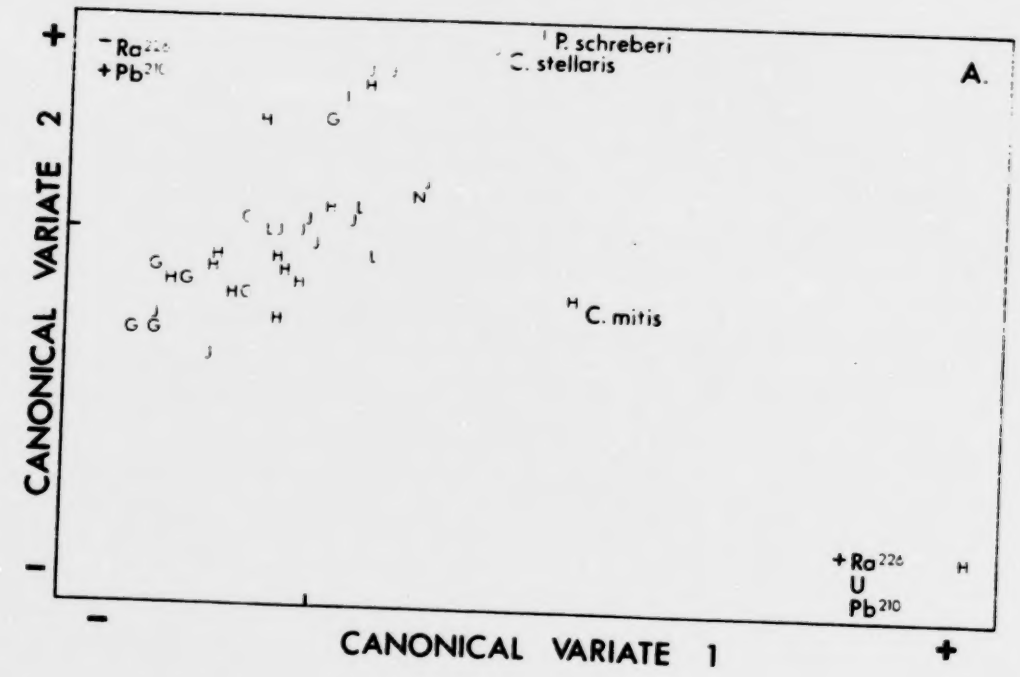
Figure 11. Canonical correlation analysis of non-vascular plant samples. Sample scores on first two canonical variates in the radionuclide domain, labelled by a) species and b) regions. One observation hidden by overlap. Signs indicate the degree of correlation of elements and radionuclides with the respective components.

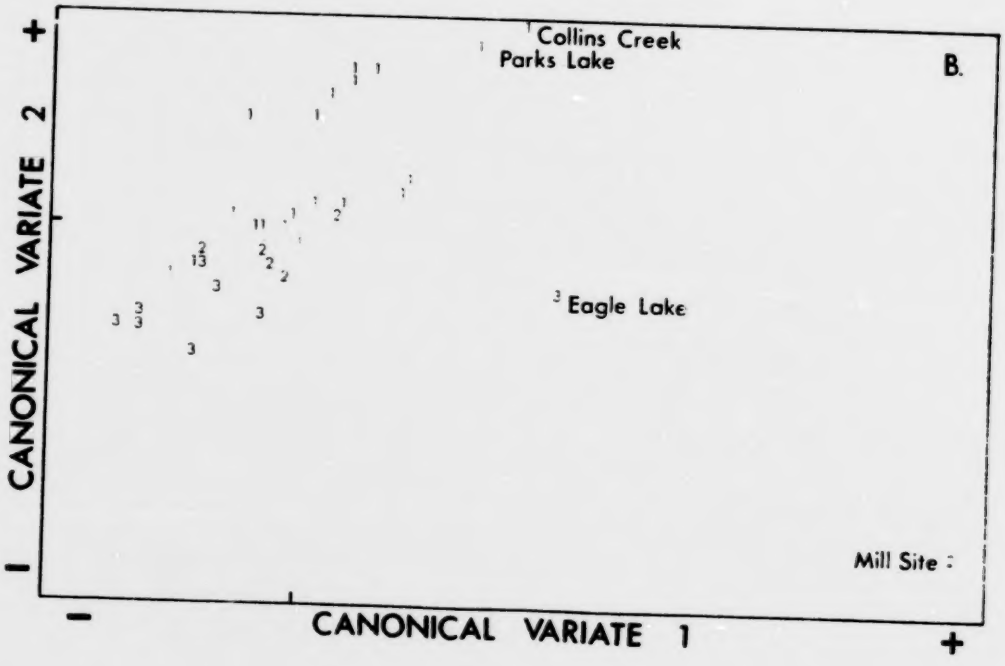
a) Species symbols

G	Cladina rangiferina	Caribou lichen
H	Cladina mitis	Caribou lichen
I	Pleurozium schreberi	Feather moss
J	Cladina stellaris	Caribou lichen
L	Stereocaulon paschale	Lichen
N	Cetraria nivalis	Lichen

b) Region symbols

1. Wollaston Bay
2. Cluff Lake
3. N. Sask./N.W.T.


− Ra226
+ Pb210
P. schreberi
C. stellaris
A.
C. mitis
+ Ra226
U
Pb210
CANONICAL VARIATE 2
CANONICAL VARIATE 1
−
+


Collins Creek
Parks Lake
B.
Eagle Lake
Mill Site
CANONICAL VARIATE 2
CANONICAL VARIATE 1
−
+

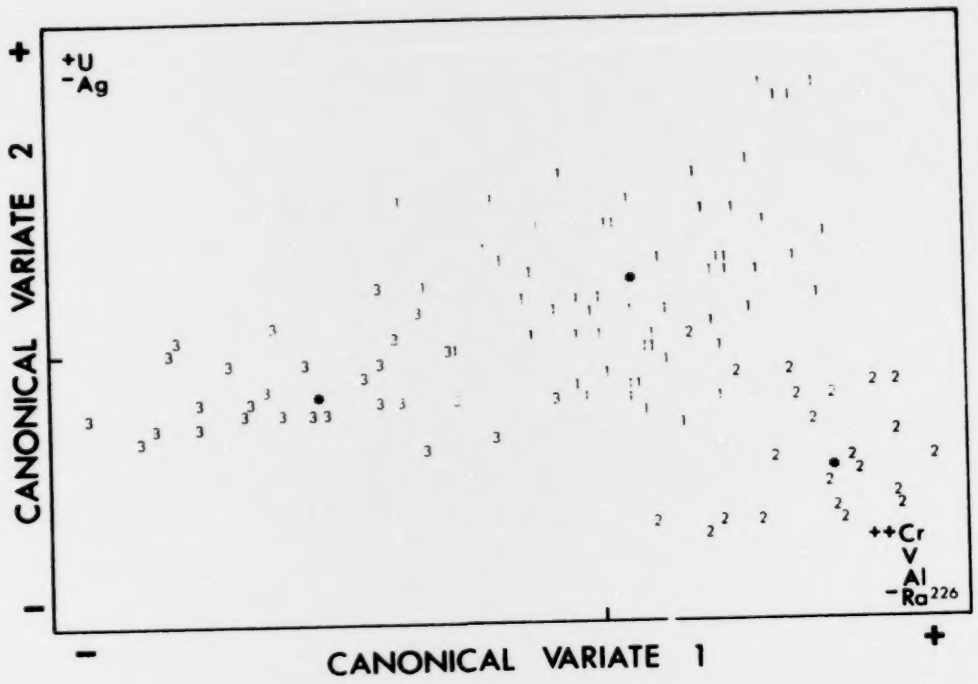


Figure 12. Canonical variates analysis by localities. Sample scores plotted on first two canonical variates and labelled by region: 1) Wollaston Lake, 2) Cluff Lake (excluding Mill Site) and 3) northernmost Saskatchewan and N.W.T. (excluding Eagle Lake). Signs indicate the degree of correlation of elements and radionuclides with the respective components. Three observations hidden by overlap. Asterisks (*) represent the centroids (bivariate means) of the sample scores for the regions.

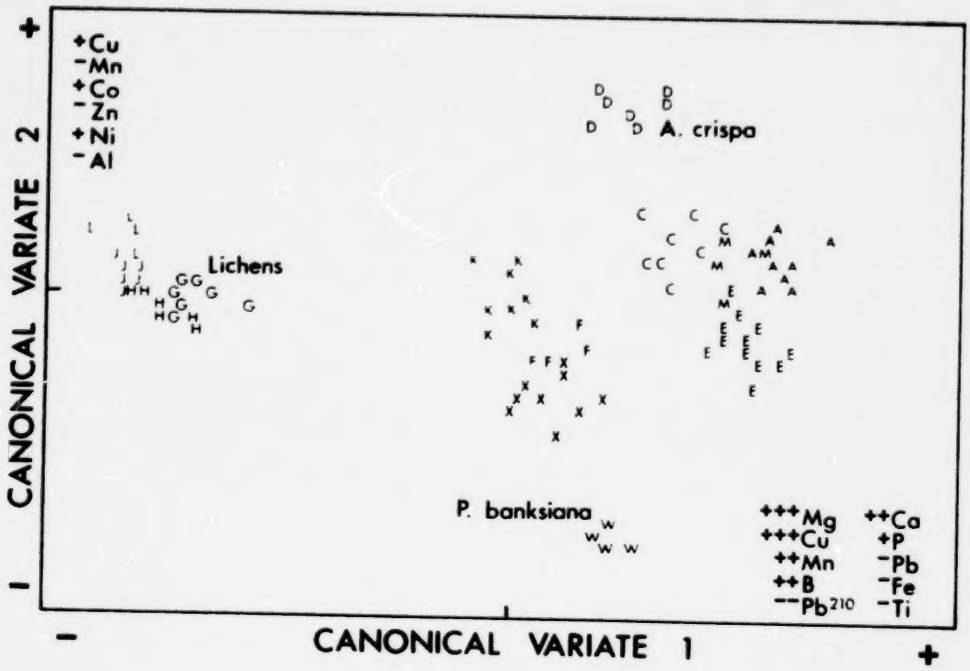


Figure 13. Canonical variates analysis by species. Sample scores on first two canonical variates. Mill Site and Eagle Lake localities excluded. Thirteen observations hidden by overlap. Signs indicate the degree of correlation of elements and radionuclides with the respective components.

A	Vaccinium myrtilloides	Canada Blueberry
B	Pinus banksiana	Jackpine
C	Ledum groenlandicum	Labrador Tea
D	Alnus crispa	Green Alder
E	Vaccinium vitis-idaea	Cranberry
F	Picea mariana	Black Spruce
G	Cladina rangiferina	Caribou Lichen
H	Cladina mitis	Caribou Lichen
J	Cladina stellaris	Caribou Lichen
K	Betula neoalaskana	Paper Birch
L	Stereocaulon paschale	Lichen
M	Empetrum nigrum	Crowberry
W	Pinus banksiana (needles)	
X	Picea mariana (needles)	

5. DISCUSSION

5.1 Variation Among Sample Sites and Species

There are differences in radionuclide concentrations among regions when compared by species group (Tables 9, 14 and 19). Lead-210 is the least variable of the three radionuclides across the regions. In contrast, there is considerable variation in uranium concentrations across regions. For example there are five- to thirty-fold differences in species-group uranium concentrations in the Wollaston and Cluff Lake regions compared to the northernmost region. There are also large differences in shrub uranium concentrations between the Wollaston and Cluff Lake regions.

The rank order of radionuclide concentration by species-group is summarized in Table 33. Lichens are high in Pb^{210} and low in Ra^{226} whereas the reverse is true for the shrubs.

There are few significant differences among regions at the species level (Table 34); two among the lichens for Pb^{210} and two among the vascular plants for uranium. Comparison among localities within regions shows uranium to possess the highest number of significant differences (20). Radium-226 also shows numerous significant differences at the locality level (14), in marked contrast to the total lack of differences at the regional level. Lead-210 has the fewest significant differences (5), a result that is explained, at least for the lichens, by the fact that Pb^{210} is widely distributed in the atmosphere.

Two localities have anomalous concentrations of radionuclides within their regions, the Mill Site in the Cluff Lake region and Eagle Lake in the northernmost region. The Mill Site is within 500 m of the Cluff Lake mill and tailings and the Eagle Lake locality is

approximately 2 km from the Eldorado mine which ceased operation in 1982. Comparative radionuclide concentration data for these localities are given in Table 35, together with data for Parks Lake in the Wollaston Lake region.

The very high ash content of the lichens at the Mill Site (Tables 6, 35) implicates dust accumulation from anthropogenic activities as the source of the high radionuclide concentrations. Relatively high Pb^{210} concentrations in the lichens may be due to accumulation of dust particles or to fallout of atmospheric aerosols resulting from radon gas decay. Further study would be necessary to separate these two effects. Radium-226 and uranium concentrations at this locality are one to two orders of magnitude larger, respectively, than elsewhere in the Cluff Lake region. The statistically significant twenty-fold increase in Ra^{226} concentration for lichens over the average for the region can only be explained by deposition in dust particles. An even greater and significant increase for uranium (83 times and 92 times, for shrubs and lichens, respectively) is also explained by atmospheric deposition. The source for uranium is probably some combination of the mill and an ore haul road which runs between the sample locality and the mill. Therefore, in the absence of high soil values for radionuclides and in the presence of high ash weights, it is suggested that the anomalous vegetation concentrations are the result of mining and milling activity adjacent to the Mill Site.

In contrast to the Mill Site, high concentrations of radionuclides at the Eagle Lake locality in the northernmost region are not associated with anomalous ash weights. They are, instead, associated with soil concentrations for each radionuclide that are a minimum of one order larger than for other localities in the region.

Both the high vegetation and soil concentrations at this locality are primarily due to anomalous values at one replicate sample site. This site was closest to a mineral exploration trench in which uranium salts were present on exposed bedrock. Thus, localized high values of uranium and its daughter radionuclides at Eagle Lake are explainable as natural phenomena. Any effects due to activity at the Eldorado mine, or a waste rock site within 1 km, would be expected to be more widespread. Dust from such activities would have been washed from the surface of vascular plants but would have been incorporated into and retained in the tissues of the lichens (caribou lichens have a normal lifespan of 20 to 40 years). As previously stated this is not evident in the ash weights. The greatest increase in radionuclide concentration at Eagle Lake is shown by shrubs for Ra^{226} (13 times) and the lichens for uranium (9 times). The Ra^{226} increase in shrubs is explained by uptake from the soil. The increase of uranium in lichens implies an atmospheric transfer which will be discussed later.

The evidence for anomalous radionuclide levels at the Mill Site and Eagle Lake localities being due to anthropogenic and natural causes, respectively, is not conclusive, but is certainly strong. If this is accepted, it is interesting to note that the high average Pb^{210} vegetation level at the Mill Site is equalled and exceeded by the average natural levels at Hidden Bay and Collins Creek, respectively, in the Wollaston Lake region. Only one species, the shrub cranberry (Vaccinium vitis-idaea) has a Pb^{210} concentration that is much greater at the Mill Site than those at the two Wollaston Lake localities. Similarly, high average Ra^{226} levels in vegetation at the Mill Site are exceeded by the higher natural levels at Eagle Lake in the northernmost region; only the lichen Cladina mitis has a considerably higher Ra^{226}

value at the Mill Site. In contrast to Pb^{210} and Ra^{226}, the high uranium concentrations in vegetation at the Mill Site are greater than baseline levels recorded elsewhere.

The Parks Lake locality is close (approx. 6 km) to the Eldor Resources mine and mill at Rabbit Lake and 4 km from the tailings area. It is therefore the locality in the Wollaston Lake region most likely to be influenced by mining activity. Relatively high concentrations of Ra^{226} and uranium (mostly significant) in the lichens at this locality are therefore of particular interest (Tables 35, 16 and 21). For both radionuclides the increase is approximately 4 times the average. This is too small an increase to conclusively implicate mining activity as the source, especially when an increase in ash weight or other evidence is absent. Furthermore, the concentration for Ra^{226} at Parks Lake is weighted by one high value for a replicate of the lichen Stereocaulon paschale (0.060 Bq/g). The high average value for this species (0.035 Bq/g) is therefore non-significant (Table 16). There is no conclusive evidence of impact by the adjacent mining activity at this locality, although the matter might be worthy of further investigation.

5.1.1 Lead-210

The concentrations of Pb^{210} found in the upland vascular vegetation in this study are generally greater than background levels for other areas reported in the literature. Concentrations in conifers at two localities in the northernmost region are marginally higher than those recorded for douglas fir (Pseudotsuga menziesii, 0.08 Bq/g) in a region of high natural radioactivity in British Columbia (Mahon and Mathewes 1983). The average level in paper birch (Betula neoalaskana, 0.10 Bq/g) greatly exceeds that of B. verrucosa (0.01 Bq/g) from Finland

(Kauranen and Miettinen 1969). Amongst the shrub species blueberry (Vaccinium myrtilloides) has the highest average concentration but green alder (Alnus crispa) has the highest maximum value (0.77 Bq/g), which is an order of magnitude higher than the concentration for grouseberry (V. scoparium, 0.07 Bq/g) recorded by Mahon (1982).

The lichens have broadly comparable average and maximum accumulations, but Cladina stellaris exceeds the concentration of C. mitis in four of five localities where they co-occur, due to its finer branching and consequent higher surface area. The highest value in this study is 0.62 Bq/g for Cladina mitis, the most widely distributed species. This value is lower than levels of a mixture of lichens (Cornicularia and Alectoria species, 1.05-2.80 Bq/g) from Alaskan tundra described by Holtzman (1966). The high Alaskan values may be explained by the exposure of the ridgetops which these lichens occupy, and their dark colour which tends to cause melting of the small amount of snow that accumulates. These factors cause them to be exposed to the atmosphere for longer periods than Cladina species, which occupy more sheltered sites (Larson and Kershaw 1975, Hutchinson-Benson et al. 1985).

Evidence from this study indicates that the distribution of Pb^{210} is primarily from the atmosphere. The average Pb^{210} concentration in lichens is approximately 5 times that of the vascular plants (Table 9). Since lichens obtain most nutrients and other elements from the atmosphere, this indicates an airborne source of radon-derived Pb^{210}. However, it is not clear what proportion of Pb^{210} accumulates by deposition from natural fallout compared to entrapment and decay of Rn^{222} as it moves upwards through the lichens from the soil. Regional differences are relatively small and suggest atmospheric dispersion

prior to deposition of Pb^{210}. However, the highest value (0.62 Bq/g, Cladina mitis) occurs at Eagle Lake and this locality has a soil concentration of Ra^{226} (the precursor of Rn^{222} and Pb^{210}) at least one order of magnitude higher than other localities. Thus, it would appear that direct entrapment of radon from the soil is occurring but that it is a relatively minor contributor to Pb^{210} concentrations in lichens, since the concentration of Pb^{210} in C. mitis at Eagle Lake is less than double the average for the species.

5.1.2 Radium-226

Maxiumum values for Ra^{226} also generally exceed those previously reported. The maximum value of 0.048 Bq/g Ra^{226} for black spruce (Picea mariana) at Eagle Lake exceeds the highest value found for conifers in the literature of 0.014 Bq/g for larch (Larix occidentalis) in British Columbia (Mahon and Mathewes 1983). Similarly, paper birch (Betula neoalaskana, 0.255 Bq/g) at Eagle Lake greatly exceeds the highest literature report for deciduous trees (willow, Salix scouleriana, 0.037 Bq/g) given by the same authors. The shrubs have higher average concentrations than the trees, with the exception of Betula neoalaskana, and all exceed the highest value found in the literature (0.0170 Bq/g, grouseberry (Vaccinium scoparium), Mahon 1982). The highest mean and maximum shrub values are for Labrador tea (Ledum groenlandicum), again at Eagle Lake. Maximum concentrations for the lichens in the present study compare with those for Cornicularia and Alectoria (Holtzman 1966), except in the case of Stereocaulon paschale (0.035 Bq/g) from Parks Lake where concentrations are double these values but may not be natural.

Shrubs have the highest Ra^{226} concentrations among the three species-groups studied. It was expected that the shrubs, being

dependent on soil nutrients, would have a higher accumulation of Ra^{226} than the lichens but it is not known why they have higher levels than the conifers. The highest average level for the shrubs occurs at the Eagle Lake locality and, as previously discussed, this locality also has the highest soil concentration.

Contamination by soil particles is a possible source of Ra^{226} in the lichens since the highest natural value for Cladina mitis (0.032 Bq/g) also occurs at Eagle Lake. However, this effect must be small, since it only represents a doubling of levels compared to the Uranium City locality, which has the second highest natural levels of Ra^{226} for lichens but has soil (and shrub) concentrations one order lower than at Eagle Lake. The precision of Ra^{226} analyses for lichens was lower than for Pb^{210} and uranium, and this also suggests some contamination by the Ra^{226} in soil particles. If the greater proportion of Pb^{210} and uranium in lichens is atmospherically derived, then these two radionuclides will be evenly distributed in the duplicate samples. In contrast, if the source of Ra^{226} in lichens is predominantly from very locally derived soil particles, then the presence of a few relatively coarse soil particles could lead to the observed lower precision for the Ra^{226} analyses of lichens.

5.1.3 Uranium

In contrast to Pb^{210} and Ra^{226}, uranium concentrations in trees and shrubs in this study are lower than some levels in the literature. The highest concentrations recorded in the literature are for black spruce (Picea mariana) twigs (3.50-24.52 $\mu g/g$) collected over the Wollaston Lake anomaly (Dunn 1983b), with a value for a single tree of 51.10 $\mu g/g$ (Dunn 1983a). These values are two orders of magnitude

greater than reported in the present study. The concentration of 0.26 μg/g uranium for the deciduous tree, paper birch (Betula neoalaskana), at Parks Lake is also less than that for Betula (0.71 μg/g) reported by Sheppard et al. (1981). Maximum values for the shrubs are also exceeded by those for speckled alder (Alnus rugosa, 1.42 /μg/g, Sheppard et al. 1981), and leatherleaf (Chaemaedaphne calyculata, 2.36 μg/g) and Labrador tea (Ledum groenlandicum, 1.45 μg/g) from the Wollaston Lake area reported by Dunn (1981).

The lower uranium levels in trees and shrubs in this study cannot be explained by stating that they represent low-level baseline localities only. For example, black spruce at McInnes Lake are over an anomaly, yet they have similar levels to those of black spruce in the Cluff Lake region, where there are no near-by anomalies. Furthermore, the Eagle Lake locality, which produced Ra^{226} levels in trees and shrubs higher than any in the literature, did not produce correspondingly high uranium levels. Clearly, factors involved in the environmental cycling and accumulation of uranium and Ra^{226} differ.

Uranium concentrations in lichens in this study are higher than literature levels. The average concentrations for four of the five lichen species collected exceed maximum background levels previously reported for Cladina species (0.53 μg/g, Sheppard et al. 1981). The lichen (and moss) concentrations exceed those for the vascular plants (Table 19) and as previously noted, this was not expected since uranium was not known to be distributed in the atmosphere. It is also of interest that the highest concentrations in lichens do not occur in localities of highest soil uranium concentrations. The source of uranium in lichens will be discussed in Section 5.3.

5.1.4 General

Soil radionuclide concentrations cannot be expected to show a close correspondence to those of the vegetation samples because, unlike the latter they were not collected throughout the area of each replicate site. Nevertheless, a weak correspondence can be detected between Ra^{226} concentrations in the soil and vascular plants. Dunn (1983a) and Sheppard and Thibault (1984) have suggested that groundwater rather than soil particles may be the source of uranium for spruce and other vascular plants. Only very limited groundwater sampling was possible in this study and only Ra^{226} showed signs of a weak positive relationship between the groundwater, soil and vegetation.

The influence of forest fires on the concentration of radionuclides in vegetation and soil has not previously been studied. The comparison of soil and two vascular species in adjacent burned and unburned situations in the Cluff Lake region showed a consistent (but non-significant) decrease in Pb^{210} and uranium concentration in two species after fire. However, Ra^{226} concentration showed a significant increase in one species. It is difficult to interpret these results and it is possible that other sources of variation between burned and unburned localities, such as small differences in soil type, are important. The effects of fire are best tested before and after controlled burning.

5.2 Relationships among radionuclides and stable elements

Profile analysis statistically confirmed the expected differences in uptake pattern of radionuclides and stable elements in the vascular and non-vascular plants. The non-vascular species preferentially accumulate a suite of crust-derived and atmospherically distributed

elements, including Pb^{210}. Vascular species preferentially accumulate essential elements taken up in solution from the soil, and were found to take up Ra^{226}.

The positions of Ra^{226} and uranium on the profiles were of particular interest. Radium-226 occupies an intermediate position between crustal elements and the nutrients. It shows little relationship to calcium, an element with which it is has been compared chemically (Whicker and Schultz 1982). Instead Ra^{226} is much closer to barium, with which it also has chemical similarities. However, it should be noted that this relationship was not duplicated by other multivariate analyses and should be viewed as very tentative. The possibility that barium can be used as a model for the uptake of Ra^{226} by vascular plants could be tested experimentally.

Uranium is located within the group of crustal elements in the profiles. This helps to confirm the unexpected conclusion of the univariate analyses that the high concentration of uranium in lichens is the result of its distribution in the atmosphere. The same result is obtained repeatedly from other multivariate analyses and a proposed source for this atmospheric uranium will be discussed in the next section.

The demonstration that the vascular and non-vascular plant samples belonged to statistically different populations required their separate treatment by some other multivariate methods such as principal components analysis (PCA).

Principal components analysis on the vascular plant data showed that radionuclides did not account for the greatest proportion of variance in the data set. Canada blueberry (Vaccinium myrtilloides) samples from the Cluff Lake region were the largest source of variance

in the data set, but this was associated with a group of nutrients and passively cycled elements rather than with the radionuclides. The second source of variance is associated with the Eagle Lake locality where green alder (Alnus crispa) has particularly high concentrations of cobalt, and paper birch (Betula neoalasakana) and Labrador tea (Ledum groenlandicum) have high values of Ra^{226}. In addition, all A. crispa samples have relatively high scores on this component based on high cobalt concentration (a required element for its nitrogen fixing system). The Wollaston Lake region samples of Vaccinium myrtilloides have relatively high scores based on Pb^{210} content. A smaller proportion of variance is associated with high concentrations of uranium in all vascular species at the Mill Site locality, Cluff Lake region. This is probably due to a combination of dust contamination and higher soil concentration than the regional average.

Principal components analysis based on the non-vascular species separates the four most northern localities on the basis of their low concentrations of crust- derived elements. This may reflect the increased frequency of air masses originating over the arctic ocean, relative to the land, in this region (Bryson, 1966). The second major source of variance is associated with high concentrations of essential elements in the moss Pleurozium schreberi and suggests that the mosses have nutrient requirements more similar to the vascular plants than the lichens. This tends to confirm the previous conclusion of Sheard (1985). There is no doubt that mosses are also efficient accumulators of airborne materials (Richardson 1981). The third source of variance, higher than for the vascular plants, isolated the Mill Site with high concentrations of Ra^{226}, silver and uranium. The smallest identifiable

source of radionuclide variance is associated with Pb^{210} concentrations in all species at Collins Creek.

The three major sources of variation for the radionuclides summarized by PCA were:

1) Radium-226 has a high correlation with the second component of the vascular plant PCA. This corresponds to high scores at the Eagle Lake locality for paper birch (Betula neoalaskana) and Labrador tea (Ledum groenlandicum), and relatively high scores for other species at this locality. These associations reflect the high natural concentrations of Ra^{226} at Eagle Lake previously discussed.

2) Lead-210 has a high correlation with component two of the vascular plant PCA and component five of the non-vascular PCA. This is respectively associated with Canada blueberry (Vaccinium myrtilloides) and the three lichen species sampled at the Collins Creek locality. This locality is 5 km from the Eldorado Resources mine and mill at Rabbit Lake but there is no evidence of high ash weights and hence of an anthropogenic dust source for elevated Pb^{210} levels. Radon-derived Pb^{210} from the mine and mill site cannot be discounted, but if this was the source evidence might also be expected from Parks Lake and Hidden Bay which are also relatively close.

3) The sixth component of the vascular and third component of the non-vascular PCA have high correlations for uranium, and uranium and Ra^{226}, respectively, associated with high scores for the Mill Site. Evidence has previously been given to suggest that these high correlations reflect anthropogenic activity adjacent to the Mill Site locality.

The principal components analyses suggest that the radionuclides are not the major sources of variance in the data set, but nevertheless

point to a number of biologically meaningful trends. However, PCA did not suggest a high degree of correlation between any radionuclide and stable element that would be of predictive value to those interested in pollution or waste disposal monitoring.

The determination of relationships between radionuclides and stable elements was more directly addressed by canonical correlation analysis (CCA), which again was applied to the vascular and non-vascular plant data sets separately. Both CCA analyses resulted in highly significant relationships between the radionuclide and stable element domains but these were based on a minority of samples with extreme radionuclide concentrations rather than general trends of predictive value. However, two conclusions from univariate analysis and PCA were confirmed and statistically validated by CCA; the Mill Site and Eagle Lake localities are outliers with respect to radionuclide concentrations in their vegetation.

Separate canonical variates analyses (CVA) were used to determine if significant differences could be detected between the localities and species sampled based on the radionuclide and stable element contents of the plant samples.

Many significant differences between localities were found by CVA and these differences were primarily between regions. The primary source of variance was in the separation of the northernmost region, Ra^{226} being one of the discriminating variables. The separation of the Wollaston and Cluff Lake regions was based primarily on high concentrations of uranium in the Wollaston region and silver in the Cluff Lake region.

Canonical variates analysis demonstrated that the species account for one order of magnitude more variance than do the locality

differences. Species analysis showed significant differences between all species belonging to different plant groups, the major source of variance being that based on the separation of lichens from the vascular species. This was based on low concentrations of nutrients and high levels of crustal elements, uranium and Pb^{210}, in the lichens and confirmed the results of profile analysis. There were also significant differences between species within groups with the exception of two pairs of lichens, (Stereocaulon paschale with Cladina mitis and C. stellaris), and crowberry (Empetrum nigrum) in the shrubs. The second major source of variance separated two vascular species on the basis of stable element content. Radium-226 was relatively unimportant in discriminating between species.

5.3 General

A major secondary objective of the study was to identify plants at the base of food chains through which radioactive and toxic elements might be transferred to man. An important result is the finding that variation between species is much greater than the variation between the localities studied. This means that the relatively high Ra^{226} concentration of vegetation in the northernmost region and also the high level of uranium in the vegetation of the Wollaston Lake region will be minor factors in comparison to differences between plant species at the base of the food chains in the area studied.

Although the results of canonical variates analysis indicate that the radionuclides are not the most important elements in discriminating between the plant species and species groups present, it is clear from both ANOVA and profile analysis that Pb^{210} and uranium are most abundant in lichens. These plants are consumed by caribou and hence are at the

base of an important food chain to man in the northern part of the area studied.

Because Pb^{210} is a bone seeker its transfer to man is mostly blocked and levels in northern residents are only moderately in excess of those for residents with southern diets (2.5 times, Hill 1966). The potential for transfer of uranium to caribou and man by this lichen-based food chain is not known. Chemical toxicity may be a greater potential hazard than radiotoxicity for uranium. The greatest potential human hazard in this food chain is from Po^{210}, which is accumulated by lichens in a similar manner to Pb^{210} (Sheard 1985), and which is known to have elevated concentrations in the flesh of caribou-eating residents of the north (Hill 1966). Further studies of this food chain would seem desirable. The community of Stony Rapids in northern Saskatchewan conducts a large, annual caribou hunt and would be a good location for a food chain study.

The present study indicates several other food chains to man that may contribute to radionuclide burden. Shrubs are an important food for moose throughout the year but browsing on high shrubs in winter is particularly important. High Ra^{226} concentrations in shrubs suggest that this radionuclide might be important in this food chain even though Ra^{226}, like Pb^{210}, is partially blocked from man because it is a bone seeker.

The food chain spruce needle → spruce grouse → man might also be a significant radionuclide pathway, especially for uranium. Uranium can occur in high concentrations in local spruce tree stands. The spruce grouse is territorial and relies on spruce needles for much of its diet, especially in fall and winter. Spruce grouse is a relatively common food item among northern residents; between 1960 and 1980 numbers of

grouse taken by hunters in northern Saskatchewan have ranged between 1,300 and 18,000 birds annually (DTRR 1980b). Therefore, this food chain is a potential pathway.

A seasonal entry of radionuclides into the human food chain might also occur in the fall through bears and more directly by man eating the fruit of blueberry (Vaccinium spp.) and other species, although limited information on the radionuclide content of wild fruit is available. Another direct impact of radionuclides could be from Labrador tea (Ledum groenlandium), depending on its present use by northerners.

There is current interest in the origins of uranium series radionuclides in the atmosphere. Jaworowski and Knownkala (1976) have implicated forest fires in addition to dust as a major contributor to Ra^{226} in the atmosphere. It has sometimes been assumed that Pb^{210} in the atmosphere is always the result of Rn^{222} decay in that environment. However, Rn^{222}/Pb^{210} and Pb^{210}/Po^{210} activity ratios indicate that these radionuclides are not in equilibrium in the atmosphere and additional sources are implicated (Moore et al. 1976). These authors have shown that plant exudates can also be important sources of Pb^{210} and Po^{210} in the atmosphere, demonstrating that approximately half the Pb^{210} content of pine needles resides in the waxy outer coating. Beauford et al. (1975, 1977) have shown experimentally that pine seedlings take up lead and zinc from soil solution and release them into the atmosphere. There are no data on the presence or absence of Ra^{226} in plant exudates.

The above studies are important because they suggest an explanation for the unexpected, high concentration of uranium in lichens observed in the present study. Preliminary studies under the senior author (unpublished) have shown that fifty percent of the uranium in jackpine (Pinus banksiana) needles resides in the surface wax layer.

This wax is continuously shed, depositing uranium on ground lichens, thereby cycling uranium back to the soil or possibly on to caribou. Since uranium is shed in particles it is probable that its distribution by the atmosphere is more localized than radon-derived Pb^{210} and Po^{210}.

The loss of radionuclides from conifers in this manner is a natural process and declining levels of uranium, Pb^{210} and other heavy metals in lichens at increasing distances from mine sites may be associated with high, localized baseline levels near the ore bodies and natural conifer cycling processes in addition to industrial activity. If this conifer cycling mechanism is substantiated, then any revegetation of tailings with conifers may not control the dispersal of radionuclides to the expected extent and could conceivably result in increased accumulations at a distance due to the submicron-sized particles involved. The cycling of radionuclides and chemotoxic elements through vegetation is a topic worthy of further investigation.

Lichens have been used to study the fallout of elements naturally distributed in the atmosphere (Puckett and Finnegan 1980), and to monitor atmospheric pollution levels (Ferry et al. 1973, Nieboer and Richardson 1981), including radionuclide fallout from airborne nuclear devices (Hutchinson-Benson et al. 1985). They have also been used to assess the levels of some naturally occurring radionuclides in the environment (Holtzman 1966) and it is evident from this study that they are appropriate plants to monitor enhanced concentrations of radionuclides in the air due to uranium mining and milling.

The use of lichens in monitoring airborne pollutants is based on their uptake of elements from the atmosphere rather than the soil. Lichens are particularly appropriate for monitoring airborne release of

Ra^{226} from uranium mining and milling operations because this radionuclide does not possess an important natural airborne pathway.

In attempting to determine if enhanced levels of uranium, Ra^{226} and Pb^{210} in vascular and non-vascular plants are associated with uranium mining, it can be important to have associated data on the levels of these radionuclides in the soil and data on the ash weights of the vegetation.

Table 33. Rank order of average concentration of radionuclides by species group (1 = low, 3 = high).

	No. species	Pb^{210}	Ra^{226}	U^{TOT}
trees	4	1	1	1
shrubs	8	1	3	2
lichens	5	3	1	3

Table 34. Number of significant differences in radionuclide concentrations (ANOVA) for species (summarized by species groups) among regions and among localities within regions.

Species group	No.[1] species	No. of Significant Differences				Percent[2] maximum
		Pb^{210}	Ra^{226}	U^{TOT}	Total	
Among regions (n=3)						
trees	4	-	-	1	1	8.3
shrubs	6	-	-	1	1	5.6
lichens	3	2	-	-	2	22.2
Total	13	2	-	2	4	10.3
Among localities within regions (n=20)						
trees	9	1	4	3	8	29.6
shrubs	12	3	6	10	19	52.8
lichens	8	1	4	7	12	37.5
Total	29	5	14	20	39	41.9

[1]Number of species present in more than one region or locality within regions, respectively.

[2]Percent maximum = Total/(No. species x 3 radionuclides)

Table 35. Average radionuclide concentration in vegetation at three anomulous sites compared to the averages for the regions excluding these sites.

	Wollaston		Cluff		N.Sask./N.W.T.	
	Avg.	Parks L.	Avg.	Mill S.	Avg.	Eagle L.
			Pb^{210} (Bq/g)			
P.mariana (needles)	<0.02	<0.02	<0.02	-	0.06*	0.09*
Shrubs	0.10	0.06	0.08	0.17	0.05	0.09
Lichens	0.41	0.41	0.34	0.47	0.28	0.62
Total vegetation	0.20	0.17	0.16	0.24	0.14	0.27
Soil	0.08	0.25	0.05	0.06	0.04	1.05
			Ra^{226} (Bq/gx100)			
P.mariana (needles)	0.21	0.24	0.16	-	0.68*	4.83*
Shrubs	1.44	1.94	0.88	3.30	1.79	22.96
Lichens	0.62	2.30	0.72	14.86	0.96	3.19
Total vegetation	0.78	1.62	0.61	6.78	1.26	12.05
Soil	4.14	5.33	1.53	1.00	4.33	210.67
			Uranium (µg/g)			
P.mariana (needles)	0.008	0.070	0.006	-	0.006*	0.004*
Shrubs	0.115	0.218	0.027	2.257	0.012	0.056
Lichens	1.034	4.147	0.191	17.674	0.045	0.409
Total vegetation	0.553	1.510	0.079	7.680	0.024	0.168
Soil	1.367	2.067	0.412	0.500	3.173	324.700
			% Ash Weight			
P.mariana (needles)	2.30	2.22	2.85	-	2.27*	1.90*
Shrubs	2.73	2.46	3.11	3.34	2.58	2.39
Lichens	1.12	1.16	1.15	1.89	0.86	1.10

* Whole shoot values

6. SUMMARY AND CONCLUSIONS

6.1 Data base

Six localities were sampled within each of three regions in northern Saskatchewan and the adjacent N.W.T. At most localities seven species and soil were sampled from three replicate sites. A total of 18 species were collected although only one was collected at all localities. The terminal 15-25 cm of the tree and tall shrub species were sampled. The needles of the conifers and the twigs of four deciduous trees and tall shrubs were analyzed. The whole, non-woody shoots of seven other shrub species were analyzed. The living portions of the lichen and moss species were sampled *in situ* and cleaned of detritus in the laboratory.

6.2 Regional and locality differences of radionuclide concentration in vegetation

Few significant differences were found between regions by analysis of variance (ANOVA) of individual species. However, when the data for the three radionuclides and 21 stable elements were analyzed simultaneously for the 13 most commonly collected species by canonical variates analysis (CVA), significant differences between the regions were detected. Radium^{226} and uranium were among the discriminating elements, Ra^{226} having a high average concentration for the northernmost Saskatchewan and N.W.T. region and uranium having a high value for the Wollaston Lake region. This CVA analysis excluded two sample localities with anomalous levels of radionuclides and stable elements, the Eagle Lake locality in the northernmost region which has naturally very high vegetation and soil concentrations, and the Mill Site locality in the Cluff Lake region with high values due to anthropogenic activity.

There is a higher proportion of significant differences in radionuclide concentrations for species among localities within regions than among regions. Lead-210 possesses the least number of significant differences between localities and uranium the most.

Apart from the two anomalous localities referred to above, the highest average concentrations for Pb^{210} in vegetation occur at Hidden Bay (0.24 Bq/g dry wt.) and Collins Creek (0.34 Bq/g dry wt.) in the Wollaston Bay region. $Radium^{226}$ has its highest average concentration at the Uranium City locality (0.24 Bq/g dry wt.) in the northernmost region. Uranium has its highest natural levels in the Wollaston Lake region (Hidden Bay 1.757 μg/g, Parks Lake 1.510 μg/g and Collins Creek 1.469 μg/g dry wt.).

It must be remembered that the average concentrations quoted above are calculated on the basis of partially different sets of species in the different localities sampled. Only one species, cranberry (Vaccinium vitis-idaea), occurred at all localities. The study illustrates the difficulty in generalizing about radionuclide concentrations in different locations because the species present vary from place to place.

6.3 Species-group and species differences in radionuclide concentration

The three species-groups sampled accumulate different concentrations of radionuclides. The trees, particularly the conifers, possess the lowest average levels of each radionuclide. The shrubs have the highest concentration of Ra^{226} and intermediate levels of uranium. The lichens have the highest concentrations of Pb^{210} and uranium.

6.3.1 Lead-210

1) The high natural concentration of Pb^{210} in the lichens comes from several undifferentiated sources. These include radon-derived Pb^{210} from atmospheric deposition, *in situ* Pb^{210} derived from radon trapped as it is continually released from the soil and probably Pb^{210} from wax shed by conifer needles.

2) Where they occur together, the caribou lichens generally accumulate Pb^{210} in the order *Cladina stellaris* > *C. mitis* > *C. rangiferina* , corresponding to their decreasing surface area per unit biomass.

3) Blueberry (*Vaccinium myrtilloides*) has the highest average accumulation among the shrubs.

4) Paper birch (*Betula neoalaskana*) has the highest average accumulation among the trees.

6.3.2 Radium-226

1) The high concentration of Ra^{226} in shrubs is considered to be due to relatively efficient uptake from the soil, and possibly groundwater.

2) Bearberry (*Arctostaphyllos uva-ursi*) has the highest average concentration among the shrubs but this is based on collections at only two localities. Labrador tea (*Ledum groenlandicum*) has the highest average of the widely sampled species.

3) Paper birch (*Betula neoalaskana*) has the highest average concentration among the tree species and in the northernmost region has accumulations comparable with the Labrador tea (*Ledum groenlandicum*).

4) The lichens all have comparably low concentrations of Ra^{226} with the exception of *Cladina mitis* whose average value is weighted by very high values at the Mill Site, Cluff Lake region. This indicates that

there is little natural airborne transport of Ra^{226} relative to Pb^{210} and uranium.

6.3.3 Uranium

1) The high concentration of uranium found in the lichens exceeds the levels in the vascular plants by the same factor (approx. 4.5 times) as Pb^{210}. This implies a substantial atmospheric input.

2) The caribou lichens generally accumulate uranium in the same order as Pb^{210}: Cladina stellaris > C. mitis > C. rangiferina. The lichen Cetraria nivalis has the highest accumulation of uranium (and Pb^{210}) at the single locality sampled.

3) Bearberry (Arctostaphyllos uva-ursi) has the highest average accumulation among the shrubs due to a high concentration at one of its two localities (Uranium City). Canada blueberry (Vaccinium myrtilloides) has the highest average concentration of the widely sampled species. Crowberry (Empetrum nigrum) has higher concentrations than other shrub species at the four localities where it was sampled.

4) Of the most widely collected tree samples, jackpine (Pinus banksiana) needles have the highest uranium concentrations even when the high level at the Mill Site, Cluff Lake region is discounted.

6.4 Radionuclide and stable element correlations

1) The vascular and non-vascular plants have significantly different patterns of element uptake (profile analysis). Lead-210 and a set of crust-derived elements (Ti, Fe, Pb, Be) and sodium have particularly high concentrations in the non-vascular plants. Six essential nutrients (Mg, B, Ca, P, Cu, Mn) characterize the element uptake patterns of the

vascular plants. Canonical variates analysis (CVA) on species gives very similar results.

2) Uranium (together with Al, V, Cr) shows a similar response pattern to the crustal elements and suggests that it is also distributed in the atmosphere (profile analysis).

3) The pattern of distribution of Ra^{226} is more closely related to that of barium than to calcium with which it is often compared (profile analysis). However, this relationship with barium was not substantiated by other analyses.

4) Differences in element uptake between species account for a much higher proportion of the variance in the element concentrations than differences between localities (CVA). Most species were shown to be significantly different from each other in element concentrations. The lichen species are more similar to each other in their uptake patterns than are the vascular species.

5) Canada blueberry (Vaccinium myrtilloides) in the Cluff Lake region is a major source of variance among the vascular plants due to high levels of some essential nutrients and passively cycled elements. Green alder, (Alnus crispa), has a high concentration of cobalt, an essential element for its nitrogen fixing system (PCA).

6) The four most northerly localities have low concentrations of crustal elements in the non-vascular species. This may indicate a relatively high frequency of air masses originating over the Arctic Ocean (PCA).

7) Mosses are non-vascular plants but are separated from the other non-vascular plants, lichens, by relatively high concentrations of nutrient elements. This indicates a greater similarity to the vascular plants than to the lichens (PCA).

8) Canonical correlation analysis carried out separately on the vascular and non-vascular species failed to detect additional correlations between the radionuclides and stable elements.

6.5 Plant species-groups at the base of potential food chains to man

1) Lichens are confirmed as important accumulators of Pb^{210} which is naturally distributed in the atmosphere. New evidence is presented which suggests that uranium is transported to lichens with the airborne waxes which are shed by conifers.

2) The newly discovered accumulation of uranium by lichens has implications for the transport of uranium via the lichen → caribou → man food chain in northern areas with extensive conifer forests.

3) Shrubs have been shown to possess relatively high concentrations of Ra^{226}. They are at the base of three food chains: moose → man, berries → man and berries → bear → man.

4) In local areas the spruce needle → spruce grouse → man food chain could potentially transport relatively high concentrations of uranium.

5) Studies of the levels and possible effects of radionuclides in the terrestrial animals of northern Saskatchewan and adjacent Northwest Territories are needed.

6.6 Effects of forest fire

No conclusive differences in radionuclide concentrations in vegetation could be detected by comparing unburned and adjacent 4-12 year old burns in the Cluff Lake region. Concentrations of Pb^{210} and uranium declined in the vegetation of burned sites, but Ra^{226} levels in the burned areas increased significantly in one species and decreased in another.

6.7 Lichens as monitors of atmospherically distributed radionuclides of anthropogenic origin

Evidence is presented which indicates that high radionuclide levels in the vegetation at the Mill Site locality, Cluff Lake region are due primarily to mining and milling activity. The accumulation of radionuclides was most pronounced for the single lichen species sampled at this locality. At other localities lichens have been shown to be efficient accumulators of natural, airborne uranium and Pb^{210}. Lichens can also accumulate airborne Ra^{226} from uranium mining and milling operations. Data on radionuclides in the associated soil, other vegetation and vegetation ash weights are useful in confirming anthropogenic sources.

6.8 Recommendations

1) It is recommended that a detailed study on the transfer of radionuclides along the lichen → caribou → man food chain be considered for northern Saskatchewan and the adjacent Northwest Territories. Such a study could be based on the community of Stony Rapids in northern Saskatchewan which undertakes an important, annual caribou hunt. Any such study should include wolves, an alternate terminal predator in the food chain. Wolves could subsequently be used to monitor the effect of radionuclide fluctuations in the atmosphere.

2) The discovery that uranium is distributed in the atmosphere, at least locally, was not expected. The suggestion that uranium and Pb^{210} are excreted in wax particles shed from conifer needles requires substantiation. Literature reports indicate that other metals can behave similarly. If verified, the phenomenon has obvious implications

regarding revegetation of tailings and spoil piles throughout the entire mining industry, and regarding interpretation of biogeochemical data. Studies should be undertaken to verify this phenomenon.

3) Lichens are efficient accumulators of airborne radionuclides and stable elements, and have the obvious potential of being used to accurately map the extent of anthropogenic effects surrounding mine and mill sites. It is recommended that a study be undertaken at a northern mine site to develop a lichen monitoring system of general applicability. An important component of the study would be to develop methods for differentiating between natural background levels (which may themselves be anomalous) and concentrations in lichens due to mining and milling activity.

4) Studies of the levels and potential effects of radionuclides in small territorial animals such as spruce grouse, hares, mice and voles may be of more importance than studies of larger, migratory or farther ranging animals. These smaller animals and their progeny may spend lifetimes in close proximity to uranium mining and milling operations. Such studies should also be given serious consideration.

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Appendix 8.1 Internal Quality Control: SRC Analytical Laboratory

Radionuclide Analysis

The SRC Laboratory is a member of the U.S. Environmental Protection Agency quality assurance program. Through this program, quality assurance samples for gross alpha, gross beta, lead-210, radium-226, thorium and uranium are sent to SRC for analysis. The accuracy of the results are then checked. In addition, the laboratory staff run standards once per day for all radionuclides being analysed and run spiked samples and duplicates for every batch of samples.

Plasma Spectroscopy

The laboratory receives National Bureau of Standards samples for accuracy checks. For example, for this study, which involved vegetation samples, NBS standard samples of orchard leaves and citrus leaves were used with every set of samples that were run through the spectrometer. Precision is monitored by running duplicates on every fifth sample.

Appendix 8.2 Multivariate statistical methods

Profile Analysis

Variables must be commensurable before profile analysis can be undertaken (Morrison 1976). Since the radionuclides and stable elements are measured in different units and scales the data were standardized to zero mean and unit variance (z-scores) using procedure CONDESCRIPTIVE of the SPSSx program package (Nie 1983) prior to analysis.

In profile analysis three separate null hypotheses are addressed.

1) Parallelism hypothesis. The profiles of the means of the variables for the groups are parallel (have the same response pattern).
2) Levels hypothesis. If parallelism is not rejected, the profiles for the two groups are at the same mean level.
3) Flatness hypotheses. If parallelism is not rejected, the variable means are equal (the pooled profile for the groups combined is flat).

Profile analysis was undertaken using SPSSx (Nie 1983), procedure MANOVA.

Principal Components Analysis (PCA)

Among multivariate techniques PCA makes the fewest statistical assumptions and has proven to be robust and useful in summarizing complex data sets in numerous ecological applications (Orloci 1978, Gauch 1982, Greig-Smith 1983, Pielou 1984). The method first involves the calculation of a correlation matrix between all possible pairs of variables (radionuclides and stable elements). Groups of correlated variables are replaced by new, synthetic attributes, the principal components resulting from the analysis. As many components are extracted as there are attributes, but if the analysis is successful

most of the variance in the original data matrix will be contained in the first few components. The dimensionality of the data matrix is thereby reduced and its interpretation simplified.

The correlations of the variables with each component are described by a set of transformation coefficients (loadings). The sum of squares of the transformation coefficients for the individual components is an expression of the relative amount of variance that each component accounts for in the correlation matrix and hence the original data matrix. The sum of squares is called the eigenvalue (or latent root) and is conveniently expressed as a percentage of the total variance (trace) for all components. The trace is equal to the sum of the elements in the principal diagonal of the matrix from which the eigenvalues are extracted. In a correlation matrix, these elements are unities (self correlations) and the trace equals the number of variables in this special case. This helps explain why the eigenvalues (and their associated components) represent a redistribution of variances in the correlation matrix and why, as a rule of thumb, interest is usually focused upon those components with eigenvalues > 1.0. The last components extracted represent the error variances of the variables and are of little interest.

The sum of squares for the transformation coefficients (loadings) across the components for each variable are termed communalities. They represent the proportion of variance of each variable accounted for by the components of interest.

Scores for the observations on the principal components may also be obtained by multiplication of the matrix of transformation coefficients by the standardized data matrix. Since there are many

observations this information is most easily represented in graphical form by ordinating the observation scores on pairs of components.

Structure in the data is identified by reference to both the table of transformation coefficients for the variables and the scores for the observations on the axes (components) of the ordination diagrams. Therefore a variable (radionuclide or stable element) with a large transformation coefficient (correlation) on a given component will result in observations (vegetation samples) being placed at one extreme of the same component in an ordination diagram. To aid in the comparison of tables and ordinations such variables are also indicated for each component on the ordination diagrams in the results section.

The full sequence of matrix operations involved in PCA is neatly summarized by Williamson (1972, Fig. 16.3). Gittins (1969) gives a more thorough but primarily nonstatistical discussion of the application of PCA in plant ecology. Principal Components Analysis was carried out using the FACTOR procedure of SAS (Ray 1982b).

Canonical Analysis

Principal components analysis is usually applied as an heuristic technique because significance levels cannot be attached to the resulting components. Canonical analysis is a related group of multivariate methods which may be used to test specific null hypotheses. Canonical analysis explores relationships between variables belonging to two separate domains (Gittins 1979). The method is analogous to PCA but whereas it is the total variance within a single set of variables that is of interest in PCA, it is the covariance between the two sets that is of central importance in canonical analysis. Pairs of canonical variates (analogous to principal components) are extracted sequentially

with the restriction that they are maximally correlated between the two domains. The correlation coefficients between the respective pairs of variates are the canonical correlation coefficients and there are as many such coefficients as the minimum number of variables in the two domains. However, unlike principal components the successive canonical variates are not orthogonal (uncorrelated) although they are commonly depicted as being so by being placed at right angles to each other in ordination diagrams.

Canonical correlation analysis (CCA) is one type of canonical analysis used in the present study. It is used to test the null hypothesis that a random relationship exists between the three radionuclides in one domain and the 21 stable elements in the other domain, accumulated by different plant species at the 20 localities sampled. If the null hypothesis is rejected, then the relationships of the variables within and between each domain are given by the correlations between the variates and the original variables (the structure matrix). This interpretation is recommended by Gittins (1979) and Williams (1983) and contrasts with the use of the canonical weights in many previous applications of the method.

Canonical variates analysis (CVA, also called canonical discriminant analysis, to be distinguished from multiple discriminant analysis) is used to test the null hypotheses that radionuclide and stable element accumulations in the vegetation are, taken together, random with respect to the species and localities sampled. Where k classes (species or localities) exist they may be described by k-1 dummy, binary variables. The two variable domains in this type of analysis are the radionuclides and the dummy, classification variables respectively. The resulting statistics are similar to those of CCA but

are limited to interpretation in the domain of the continuous variables (the radionuclides). In CVA k-1 canonical variates are extracted. The significance of differences between the classes under consideration is assessed on the basis of Mahalanobis' distances calculated between all pairs of classes.

The canonical analyses were carried out using the SAS package (Ray 1982b), specifically the CANCORR procedure for CCA and the CANDISC procedure for CVA.

Appendix 8.3 Original Vegetation and Soil Data

Species codes

1 Vaccinium myrtilloides
2 Pinus banksiana
3 Ledum groenlandicum
4 Alnus crispa
5 Vaccinium vitis-idaea
6 Picea mariana
7 Cladina rangiferina
8 Cladina mitis
9 Pleurozium schreberi
10 Cladina stellaris
11 Betula neoalaskana
12 Stereocaulon paschale
13 Empetrum nigrum
14 Cetraria nivalis
15 Populus tremuloides
16 Arctostaphyllos uva-ursi
20 Vaccinium uliginosum
21 Juniperus communis
29 Pinus banksiana (needles)
69 Picea mariana (needles)
22 Soil

Locality codes

Wollaston Bay region

1 Hidden Bay
2 Collins Creek
5 Hungry Island
6 Cunning Bay
7 Parks Lake
8 Labach Lake
9 Midwest Lake
10 Minor Bay

Cluff Lake region

11 Carswell Lake
12 South Gate
13 Carswell North
14 Jolley Lake
15 Sandy Lake
16 Mill Site

N. Sask./N.W.T.

17 Uranium City
18 Eagle Lake
19 Tazin River
20 Ena Lake
21 McInnes Lake
22 Dunvegan Lake

Variable units of measurement

Pb^{210} Bq/g dry weight

Ra^{226} Bq/g ash weight

uranium - barium ug/g ash weight

TRNSF percentage ash weight

FIRE 1 present (Cluff Lake), 0 absent

NEED 1 needles only, 0 needles plus twigs (conifers)

LOI percentage loss on ignition (soil)

H_2O percentage water (soil)

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	PB210	RA226	URAN	BORON	PHOSPH	SILV	ALUMIN	BER	CALCIUM	CADM	COB	CHROM	COPP	IRON	POTASS
1	1	0.20	0.450	17.0	310	31000	8.3	5900	0.2	170000	1.0	0.7	10.0	120.0	2600.0	22000
1	1	0.19	0.250	15.0	300	34000	19.0	4600	0.2	150000	1.9	1.4	16.0	150.0	2700.0	36000
1	1	0.15	0.350	17.0	340	35000	20.0	5400	0.2	140000	2.4	0.7	17.0	170.0	2100.0	34000
1	2	0.30	0.700	20.0	150	39000	3.0	5800	0.4	200000	0.9	2.2	9.2	170.0	2700.0	97000
1	2	0.30	1.000	21.0	210	35000	0.2	6000	0.5	180000	0.7	0.9	14.0	150.0	3000.0	84000
1	2	0.20	0.800	23.0	160	40000	2.9	6100	0.4	120000	0.7	2.0	8.6	240.0	3000.0	30000
1	5	0.17	1.200	6.4	280	34500	2.4	5500	0.6	190000	1.4	2.0	16.5	220.0	2800.0	115000
1	5	0.15	0.500	5.4	320	32000	2.3	5300	0.5	210000	2.0	2.0	11.0	170.0	2200.0	58000
1	5	0.13	0.850	1.5	330	38000	7.8	4500	0.5	250000	1.9	2.0	15.0	250.0	2100.0	120000
1	6	0.17	0.500	1.5	240	47000	2.8	6000	1.2	210000	0.8	2.5	11.0	240.0	2900.0	57000
1	6	0.12	0.300	1.4	280	35000	2.8	5800	1.0	180000	1.2	3.5	15.0	180.0	3700.0	47000
1	6	0.10	0.750	1.4	220	49000	1.0	5000	0.6	230000	0.5	0.9	7.6	220.0	2200.0	120000
1	8	0.14	0.600	0.4	420	38000	7.8	6200	0.5	190000	0.8	1.3	8.8	180.0	2000.0	41000
1	8	0.16	0.550	0.4	900	30000	13.0	5300	0.5	180000	0.9	1.4	15.0	210.0	2600.0	120000
1	8	0.15	0.500	1.0	390	39000	7.4	6000	0.5	190000	1.2	0.5	9.8	130.0	2400.0	120000
1	9	0.13	0.410	3.1	370	40000	6.9	5400	0.5	230000	1.1	0.7	14.0	140.0	2200.0	110000
1	9	0.07	0.450	2.4	470	43000	9.0	5200	0.5	190000	1.2	0.8	13.0	200.0	2500.0	120000
1	9	0.14	0.450	2.7	440	34500	6.6	5000	0.5	178000	0.5	1.2	13.0	160.0	2300.0	108000
1	10	0.12	0.350	1.9	300	35000	5.1	6000	1.1	210000	1.4	4.0	21.0	200.0	4000.0	57000
1	10	0.18	0.400	0.9	320	36000	4.0	5200	0.5	180000	0.6	2.1	8.1	150.0	1900.0	55000
1	10	0.16	0.350	1.1	240	48000	9.9	7000	0.5	230000	1.0	2.3	12.0	270.0	2300.0	53000
1	11	0.09	0.300	1.1	530	36000	22.0	4900	0.5	180000	1.6	2.6	22.0	200.0	2800.0	97000
1	11	0.12	0.350	0.8	950	35000	24.0	5000	0.5	220000	1.8	1.0	20.0	160.0	2400.0	87000
1	11	0.12	0.200	0.9	780	30000	16.0	5100	0.5	220000	1.6	1.4	14.0	110.0	2200.0	41000
1	12	0.12	0.200	1.1	1400	35000	13.0	5900	0.5	220000	0.5	2.2	18.0	210.0	3000.0	52000
1	12	0.09	0.250	1.1	920	31000	38.0	6200	0.5	180000	2.2	1.3	26.0	160.0	2900.0	93000
1	12	0.12	0.400	0.9	900	30000	32.0	6300	0.5	190000	1.8	2.3	34.0	200.0	3800.0	90000
1	12	0.14	0.300	1.1	780	37000	38.0	7300	0.5	230000	2.9	2.0	21.0	160.0	2900.0	93000
1	12	0.11	0.400	0.7	960	44000	10.0	6000	0.5	240000	1.3	2.2	14.0	120.0	2200.0	120000
1	12	0.08	0.250	0.6	720	38000	12.0	4700	0.5	240000	1.3	0.6	13.0	140.0	1800.0	120000
1	13	0.11	0.190	0.3	840	37000	26.0	5400	0.5	200000	1.6	1.5	24.0	200.0	4100.0	41000
1	13	0.10	0.250	0.3	1500	32000	21.0	5200	0.5	190000	1.3	0.6	21.0	130.0	2700.0	96000
1	13	0.10	0.350	0.7	860	34000	11.0	5200	0.5	190000	0.7	1.2	11.0	140.0	2000.0	38000
1	13	0.11	0.450	0.3	1100	36000	9.0	4100	0.5	210000	0.5	1.3	11.0	140.0	1700.0	53000
1	13	0.11	0.500	0.2	1100	37000	9.9	6100	0.5	270000	0.9	1.2	11.0	160.0	2100.0	100000
1	13	0.08	0.650	0.3	1100	40000	7.2	4800	0.5	280000	0.6	0.8	8.1	140.0	1500.0	88000
1	14	0.09	0.250	0.7	550	35000	30.0	5000	0.5	210000	1.7	0.8	23.0	160.0	3000.0	40000
1	14	0.18	0.250	2.0	800	33000	15.0	7800	0.5	170000	1.2	1.0	20.0	150.0	3300.0	46000
1	14	0.10	0.250	1.2	735	39500	12.0	7400	0.5	200000	0.7	1.1	16.5	165.0	2750.0	41000
1	14	0.11	0.750	0.8	960	36000	7.9	7100	0.5	200000	0.9	1.5	11.0	120.0	2200.0	48000
1	14	0.11	0.700	0.9	880	34500	5.4	5900	0.5	204000	1.0	1.4	14.0	150.0	2200.0	109000
1	14	0.07	0.400	0.5	870	41000	3.1	4900	0.5	220000	0.6	0.9	7.7	140.0	1700.0	40000
1	15	0.11	0.250	2.7	960	32400	16.0	5700	0.5	194000	1.4	1.4	13.0	170.0	2400.0	80300
1	15	0.08	0.250	1.3	1600	37000	20.0	4800	0.5	190000	1.2	1.5	14.0	130.0	2300.0	44000
1	15	0.12	0.300	1.3	840	28000	21.0	4200	0.5	180000	1.2	0.6	14.0	120.0	2000.0	38000
1	15	0.07	0.450	<0.1	580	38500	13.0	5400	0.5	186000	2.1	0.8	14.0	74.0	1700.0	117000
1	15	0.07	0.400	0.4	750	38500	13.0	5400	0.5	187000	1.6	0.6	16.0	140.0	1800.0	114000
1	15	0.06	0.350	0.4	690	33500	22.0	3800	0.5	190000	2.2	1.7	15.0	130.0	1800.0	35500
1	16	0.19	1.000	102.0	680	26800	19.0	7700	0.5	156000	1.0	1.3	18.0	92.0	3300.0	75000
1	16	0.17	1.300	93.0	880	30800	12.0	6800	0.5	175000	0.7	0.6	16.0	130.0	2900.0	83600
1	16	0.19	1.100	129.0	860	29700	14.0	7700	0.5	175000	1.0	1.6	16.0	130.0	3300.0	81100
1	16	0.19	1.400	108.0	800	26800	9.5	8000	0.5	202000	0.8	1.3	18.0	150.0	3300.0	73600
1	16	0.18	1.400	101.0	830	31600	15.0	8100	0.5	174000	0.9	1.5	20.0	130.0	3800.0	95700
1	16	0.15	1.100	64.0	570	30300	14.0	6800	0.5	177000	0.9	1.1	20.0	120.0	3000.0	83800
2	1	0.05	0.050	24.0	390	35700	5.9	17400	1.0	176000	7.9	4.2	33.0	77.0	2500.0	124000

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	RB210	RA226	URAN	BORON	PHOSPH	SILV	ALUMIN	BER	CALCIUM	CROM	COB	CHROM	COPP	IRON	POTASS
2	1	0.04	0.080	22.0	330	39000	3.8	18100	0.9	158000	11.0	3.5	28.0	85.0	2400.0	133000
2	1	0.03	0.120	27.0	480	37800	5.2	13300	1.0	133000	5.8	5.4	32.0	110.0	2400.0	146000
2	11	0.02	0.070	0.9	490	41000	4.6	24000	0.9	210000	5.3	3.3	19.0	61.0	2300.0	46000
2	11	0.04	0.070	0.8	320	36000	4.1	23000	0.6	230000	6.0	2.0	17.0	62.0	1900.0	53000
2	11	0.05	0.060	1.6	502	36000	4.9	22000	0.6	270000	6.6	2.2	16.0	54.0	2100.0	37000
2	12	0.05	0.200	0.6	410	40000	8.8	21000	0.5	220000	5.4	2.8	17.0	61.0	2300.0	49000
2	12	0.07	0.050	0.4	401	44000	5.4	23000	0.7	300000	4.6	2.2	17.0	60.0	2000.0	53000
2	12	0.06	0.060	0.3	350	37000	3.0	24000	0.6	200000	2.3	1.4	15.0	52.0	1500.0	90000
2	12	0.04	0.040	0.3	470	51000	3.0	30000	0.5	160000	2.5	2.2	14.0	79.0	1500.0	120000
2	12	0.04	0.120	0.8	420	58000	4.6	30000	0.5	170000	3.3	2.0	14.0	95.0	1900.0	66000
2	12	0.05	0.090	0.7	400	55000	4.6	29000	0.8	180000	4.0	3.4	18.0	83.0	2100.0	95000
2	13	0.02	0.080	0.2	335	42000	3.8	20500	0.8	230000	8.1	3.1	18.0	64.0	1950.0	77500
2	13	0.04	0.070	0.6	430	35000	2.6	16000	0.5	220000	4.9	0.8	14.0	44.0	1500.0	88000
2	13	0.09	0.110	0.2	460	36000	3.4	19000	0.6	240000	6.2	1.8	13.0	44.0	1700.0	59000
2	13	0.03	0.070	0.4	780	55000	2.7	27000	0.5	180000	3.4	0.6	12.0	70.0	1500.0	79000
2	13	0.04	0.130	0.2	660	48000	3.2	32000	0.6	200000	4.7	1.5	16.0	50.0	1400.0	100000
2	13	0.03	0.070	0.2	770	59000	1.9	30000	0.7	200000	7.8	0.5	17.0	76.0	2100.0	73000
2	14	0.03	0.050	0.7	410	35000	4.6	16000	0.5	220000	5.3	1.2	12.0	50.0	1800.0	88000
2	14	0.04	0.060	1.4	640	38000	4.9	14000	0.5	240000	7.3	0.5	16.0	64.0	2500.0	77000
2	14	0.03	0.070	0.6	480	43000	6.7	13000	0.5	280000	13.0	1.3	15.0	63.0	2400.0	37000
2	14	0.02	0.050	0.5	380	72000	7.1	25000	0.7	140000	8.7	2.1	23.0	120.0	2100.0	110000
2	14	0.03	0.050	0.6	420	93000	4.2	29000	0.7	120000	9.1	1.8	21.0	150.0	2300.0	86000
2	14	0.03	0.050	0.5	440	72000	2.7	27000	0.6	170000	8.1	2.1	17.0	140.0	1700.0	100000
2	15	0.10	0.070	1.7	350	42000	11.0	20000	0.9	230000	7.7	6.3	21.0	68.0	2900.0	30000
2	15	0.05	0.190	2.3	430	37000	7.0	22000	0.6	220000	5.7	3.5	18.0	71.0	2500.0	25000
2	15	0.13	0.130	1.1	330	46000	11.0	25000	0.7	220000	5.9	4.1	19.0	61.0	2400.0	41000
2	15	0.02	0.070	0.3	340	79000	5.8	34000	1.0	130000	12.0	3.2	20.0	140.0	2300.0	75000
2	15	0.03	0.060	0.2	600	72000	7.5	40000	0.6	130000	2.5	2.0	17.0	94.0	1400.0	110000
2	15	0.02	0.090	1.0	450	74000	6.5	39000	1.0	135000	4.7	3.5	21.0	110.0	1800.0	56000
2	16	0.07	0.700	91.0	250	28000	5.4	22000	1.0	210000	7.0	3.9	23.0	48.0	3700.0	49000
2	16	0.06	0.700	140.0	300	35000	5.1	22000	0.7	200000	4.0	2.1	17.0	58.0	2900.0	91000
2	16	0.08	0.900	101.0	438	34000	5.0	20000	0.8	260000	4.4	2.2	16.0	52.0	2900.0	70000
2	16	0.08	0.800	117.0	290	34000	3.5	22000	1.1	210000	3.3	3.0	14.0	57.0	2900.0	110000
2	16	0.07	0.700	114.0	350	37000	3.7	25000	0.6	230000	3.3	2.1	15.0	42.0	2300.0	89000
2	16	0.40	1.200	139.0	310	41000	4.8	27000	1.4	230000	3.0	4.3	31.0	53.0	4200.0	63000
2	17	0.03	0.130	0.7	270	52000	5.0	28000	0.5	180000	4.0	6.0	12.0	93.0	1800.0	40000
2	17	0.03	0.250	0.7	210	54000	3.0	26000	0.5	190000	5.0	5.0	10.0	100.0	1600.0	100000
2	17	0.03	0.250	1.0	260	62000	4.0	24000	0.5	140000	3.0	2.0	8.0	98.0	1700.0	51000
2	18	0.05	1.000	0.5	890	58000	9.0	23000	0.6	145000	4.0	22.0	12.0	120.0	2000.0	49000
2	18	0.07	0.350	1.7	200	56000	5.0	22000	0.5	180000	7.0	21.0	13.0	120.0	2400.0	90000
2	18	0.04	0.180	2.8	230	43000	9.0	23000	0.5	200000	4.0	52.0	13.0	81.0	2200.0	89000
2	19	0.09	0.110	0.3	140	45000	2.0	16000	0.5	220000	4.0	2.0	5.0	72.0	1600.0	68000
2	19	0.04	0.080	0.2	73	36000	2.0	11000	0.5	130000	4.0	2.0	5.0	66.0	1300.0	42000
2	19	0.12	0.140	0.2	100	42000	2.0	17000	0.7	200000	5.0	5.0	9.0	81.0	1600.0	47000
2	20	0.09	0.160	4.2	185	56000	3.0	27000	0.5	175000	4.5	9.5	11.0	100.0	1550.0	51500
2	20	0.10	0.300	0.3	140	54000	3.0	21000	0.5	210000	4.0	7.0	11.0	86.0	1600.0	92000
2	20	0.07	0.080	0.5	160	63000	2.0	20000	0.5	210000	8.0	8.0	9.0	120.0	1850.0	80000
3	1	0.06	0.400	6.4	510	3000	1.8	2000	1.0	211000	3.0	1.6	11.0	190.0	1600.0	188000
3	1	0.06	0.700	5.6	470	37700	4.3	2200	0.5	208000	0.6	1.3	14.0	210.0	1600.0	122000
3	1	0.08	0.300	7.2	550	42700	2.4	2000	0.5	192000	0.5	0.5	13.0	140.0	1800.0	126000
3	2	0.08	0.650	5.3	310	41500	2.0	2400	1.0	243000	1.0	1.0	7.6	140.0	1300.0	169000
3	2	0.09	0.600	7.0	360	38600	0.5	2800	0.5	231000	0.5	0.5	8.6	140.0	1400.0	186000
3	2	0.06	0.700	4.5	350	44600	1.6	2200	1.0	211000	1.0	1.0	8.0	160.0	1200.0	195000
3	6	0.04	0.600	0.6	290	47100	4.7	3400	0.5	218000	0.8	1.7	10.0	140.0	1700.0	94500
3	6	0.05	0.800	0.4	300	53200	4.4	2700	0.5	245000	0.8	0.5	11.0	190.0	1300.0	128000

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	PB210	RA226	URAN	BORON	PHOSPH	SILV	ALUMIN	BER	CALCIUM	CADM	COB	CHROM	COPP	IRON	POTASS
3	6	0.07	1.400	0.9	290	50800	6.8	3500	0.5	238000	0.7	1.7	10.0	130.0	1600.0	105000
3	7	0.06	1.000	7.5	220	42700	2.8	4000	0.5	291000	0.6	0.6	7.7	120.0	1400.0	111000
3	7	0.07	0.850	18.0	320	45000	2.0	6900	0.7	240000	0.7	2.0	12.0	170.0	2500.0	160000
3	7	0.06	0.850	11.0	450	41000	4.3	5500	0.7	289000	1.7	1.2	12.0	160.0	2400.0	113000
3	8	0.04	0.700	0.2	410	42400	6.6	4700	0.5	242000	0.8	2.1	12.0	130.0	1900.0	110000
3	8	0.05	0.850	0.8	560	40200	7.6	6000	0.9	263000	1.4	2.3	13.0	160.0	2700.0	108000
3	8	0.11	0.650	0.5	510	33000	5.0	5100	0.5	280000	0.9	1.5	15.0	130.0	2200.0	130000
3	9	0.07	0.950	2.8	310	40300	3.1	5700	0.5	274000	0.7	1.1	10.0	130.0	2000.0	124000
3	9	0.06	0.700	1.2	610	40000	4.0	3700	0.5	280000	0.5	2.0	12.0	140.0	2000.0	140000
3	9	0.05	0.750	1.5	440	39600	3.4	4200	0.5	290000	0.5	1.8	11.0	130.0	1900.0	83200
3	10	0.04	0.450	0.9	380	39600	5.5	5500	0.5	238000	0.5	0.6	13.0	100.0	2100.0	74200
3	10	0.04	0.450	0.7	500	44500	7.6	4500	0.5	266000	1.0	1.1	14.0	160.0	2000.0	83300
3	10	0.05	0.550	0.5	380	36500	6.9	4300	0.5	265000	0.7	1.3	10.0	120.0	2000.0	79200
3	17	0.05	0.700	1.2	570	38000	4.0	3300	0.5	210000	0.5	2.0	6.0	170.0	2300.0	93000
3	18	0.08	35.000	1.5	550	43000	6.0	2000	0.5	220000	0.5	4.0	3.0	170.0	1400.0	86000
3	18	0.06	5.000	2.2	650	37000	9.0	2000	0.5	200000	0.5	2.0	9.0	140.0	1600.0	110000
3	18	0.05	3.500	1.5	390	33000	8.0	2600	0.5	220000	0.5	2.0	6.0	100.0	1200.0	95000
3	19	0.07	0.680	0.1	490	47500	5.0	2200	0.5	215000	0.5	2.0	4.0	215.0	1350.0	89000
3	19	0.07	0.600	0.1	420	48000	4.0	3500	0.5	230000	0.5	2.0	3.0	190.0	1300.0	100000
3	19	0.07	0.600	0.2	475	41500	6.0	3400	0.5	200000	0.5	1.0	5.5	200.0	1200.0	101000
3	20	0.06	0.400	0.5	440	46000	2.0	2100	0.5	250000	0.5	0.5	8.0	190.0	1200.0	110000
3	20	0.03	0.450	0.2	440	49000	8.0	2300	0.5	220000	0.6	0.7	3.0	160.0	1100.0	160000
3	20	0.05	0.350	0.3	370	52000	2.0	2600	0.5	220000	2.0	7.0	2.0	190.0	1200.0	73000
3	21	0.06	1.600	0.2	720	48000	10.0	2400	0.5	220000	0.9	1.0	5.0	180.0	1300.0	110000
3	21	0.02	0.850	0.1	690	43000	10.0	1300	0.5	180000	0.5	0.9	2.0	120.0	820.0	76000
3	21	0.02	0.850	0.2	520	54000	8.0	1640	0.5	180000	0.5	0.5	5.0	170.0	890.0	47000
3	22	0.09	0.600	0.2	520	46000	5.0	3800	0.5	240000	0.5	1.0	6.0	170.0	1400.0	110000
3	22	0.06	0.500	0.2	490	44000	3.0	1700	0.5	200000	0.5	0.5	2.0	130.0	1100.0	86000
3	22	0.06	0.450	0.2	460	37000	5.0	1700	0.5	190000	0.5	0.5	3.0	120.0	880.0	16000
4	2	0.16	0.250	3.9	410	68000	0.4	8300	2.0	110000	0.2	24.0	7.2	120.0	2500.0	73000
4	2	0.11	0.200	4.4	150	49000	0.2	3800	1.1	110000	0.6	18.0	5.2	150.0	500.0	86000
4	2	0.12	0.250	3.8	160	68000	<0.2	8400	2.3	120000	0.2	29.0	7.6	120.0	3300.0	120000
4	5	0.18	0.800	1.7	.	.	.	.	.	.	.	.	.	.	.	.
4	5	0.15	1.000	1.9	.	.	.	.	.	.	.	.	.	.	.	.
4	5	0.23	1.300	3.2	310	37500	0.5	3300	1.5	194000	3.2	21.0	23.0	350.0	3800.0	106000
4	7	0.08	.	5.3	.	.	.	.	.	.	.	.	.	.	.	.
4	7	.	.	1.0	.	.	.	.	.	.	.	.	.	.	.	.
4	7	0.08	.	4.0	.	.	.	.	.	.	.	.	.	.	.	.
4	10	0.05	0.400	<0.1	310	55100	1.0	2800	1.3	178000	1.1	10.0	22.0	280.0	2700.0	167000
4	10	.	0.250	<0.1	.	.	.	.	.	.	.	.	.	.	.	.
4	10	0.13	0.600	0.3	.	.	.	.	.	.	.	.	.	.	.	.
4	11	0.06	0.250	0.9	470	39800	1.4	1300	0.8	277000	0.6	5.2	7.5	160.0	1500.0	83400
4	11	0.07	0.300	0.7	320	28300	1.7	1000	0.5	349000	0.5	4.3	8.8	140.0	1200.0	76100
4	11	0.08	0.450	1.4	350	35600	1.5	1500	0.6	387000	0.7	5.8	8.2	140.0	1700.0	94800
4	12	0.05	0.300	<0.1	310	29700	2.7	1600	0.5	328000	1.4	3.8	12.0	130.0	2100.0	89100
4	12	0.07	0.350	0.3	400	38400	1.2	1600	0.9	307000	1.0	5.5	15.0	170.0	2200.0	110000
4	12	0.09	0.200	0.7	340	39000	0.5	2700	0.8	270000	0.9	3.7	7.9	180.0	2100.0	120000
4	16	0.05	0.700	35.0	190	43300	0.5	1700	0.5	264000	0.5	2.6	5.3	150.0	1300.0	113000
4	16	0.18	1.900	172.0	240	40300	0.5	5200	1.0	286000	0.5	5.0	11.0	200.0	3000.0	121000
4	16	0.07	1.000	72.0	230	49300	3.1	3200	0.7	267000	0.5	4.8	9.8	170.0	2200.0	124000
4	17	0.07	0.500	1.6	290	38000	5.0	3500	1.0	260000	1.0	8.0	10.0	220.0	2800.0	90000
4	17	0.04	0.600	0.4	420	38000	5.0	1600	1.0	240000	1.0	21.0	7.0	340.0	1900.0	120000
4	17	0.06	0.900	1.1	145	18500	0.6	380	0.5	32000	0.5	2.0	4.0	53.5	630.0	45500
4	18	0.22	19.000	3.3	360	38000	5.0	1300	1.0	240000	1.0	56.0	7.0	430.0	2100.0	120000
4	18	0.15	4.700	2.2	560	40000	5.0	2000	1.0	260000	1.0	65.0	8.0	600.0	2400.0	130000

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	PB210	RA226	URAN	BORON	PHOSPH	SILV	ALUMIN	BER	CALCIUM	CADM	COB	CHROM	COPP	IRON	POTASS
4	18	0.12	3.800	2.9	380	41000	5.0	2900	1.0	220000	1.0	76.0	7.0	580.0	2000.0	120000
4	19	0.06	0.160	0.2	250	35000	1.0	670	0.5	260000	1.0	4.0	4.0	120.0	1400.0	87000
4	19	0.04	0.400	0.2	300	61000	5.0	980	1.0	220000	1.0	8.0	7.0	340.0	1700.0	170000
4	19	0.04	0.190	0.2	340	41000	5.0	820	1.0	240000	1.0	8.0	7.0	180.0	1300.0	150000
4	20	0.05	0.160	0.2	190	48000	5.0	1100	1.0	260000	3.0	8.0	8.0	300.0	1500.0	160000
4	20	0.07	0.200	0.2	320	48000	5.0	1400	1.0	260000	1.0	19.0	6.0	500.0	1700.0	120000
4	20	0.10	0.400	0.4	240	44000	5.0	1900	1.0	250000	2.0	13.0	8.0	420.0	1600.0	110000
5	1	0.05	0.300	8.3	250	31700	3.4	4000	0.5	214000	1.8	0.5	11.0	140.0	1100.0	132000
5	1	0.13	0.090	9.2	270	38100	7.5	5100	0.5	184000	1.0	0.8	11.0	170.0	800.0	140000
5	1	0.05	0.170	7.0	400	42300	7.1	3500	0.5	175000	1.3	0.8	12.0	220.0	900.0	112000
5	2	0.04	0.300	7.4	230	35000	3.7	3600	0.2	180000	0.3	0.9	7.2	120.0	1200.0	70000
5	2	0.06	0.400	11.0	180	25000	4.5	5500	0.2	260000	0.7	1.3	8.0	120.0	1400.0	86000
5	2	0.04	0.400	9.1	260	31000	5.2	3900	0.2	220000	0.7	0.8	8.2	120.0	1300.0	64000
5	5	0.03	0.600	2.1	250	39000	4.0	4700	0.5	280000	1.0	1.0	7.0	200.0	1200.0	100000
5	5	0.02	0.400	2.1	190	28000	8.0	4200	0.5	270000	3.0	2.0	9.0	130.0	1300.0	94000
5	5	0.04	1.000	1.3	200	35000	6.0	4400	0.5	260000	2.0	1.0	11.0	160.0	1000.0	140000
5	6	0.04	0.350	1.0	190	50000	8.0	4600	0.5	230000	0.9	0.5	12.0	170.0	1100.0	150000
5	6	0.07	0.400	0.9	240	36000	6.0	5300	0.5	250000	1.0	2.0	9.0	150.0	1800.0	89000
5	6	0.06	0.500	0.3	180	30000	8.0	4700	0.5	220000	2.0	7.0	9.0	150.0	1200.0	80000
5	7	0.02	0.600	12.0	300	38000	5.0	5500	0.5	280000	0.9	2.0	10.0	130.0	1300.0	90000
5	7	0.03	0.500	8.4	200	33000	3.0	4400	0.5	280000	0.8	0.8	8.0	130.0	90.0	130000
5	7	0.04	0.700	12.0	230	35000	7.0	5600	0.5	260000	0.7	0.9	19.0	140.0	1100.0	120000
5	8	0.05	0.700	0.2	290	33000	7.0	5600	0.5	270000	2.0	1.0	10.0	120.0	1500.0	97000
5	8	0.02	0.350	0.5	270	36000	16.0	5800	0.5	280000	2.0	0.5	11.0	170.0	1200.0	120000
5	8	0.03	0.600	0.2	280	27000	16.0	9400	0.5	240000	3.0	0.8	15.0	120.0	1800.0	91000
5	9	0.04	0.400	3.1	330	30000	10.0	6000	0.5	240000	1.0	0.7	10.0	110.0	1200.0	58000
5	9	0.05	0.300	1.9	330	31000	10.0	9500	0.5	240000	3.0	1.0	17.0	120.0	2000.0	65000
5	9	0.02	0.350	2.0	370	32000	14.0	8600	0.5	280000	1.0	0.6	12.0	140.0	1100.0	120000
5	10	0.04	0.350	0.5	230	31000	14.0	5400	0.5	260000	1.0	0.7	13.0	130.0	1100.0	120000
5	10	0.05	0.450	0.7	230	29000	6.0	6400	0.5	280000	0.5	0.5	10.0	120.0	1400.0	76000
5	10	0.05	0.300	0.7	250	33000	17.0	5900	0.5	270000	1.0	1.0	13.0	150.0	1400.0	130000
5	11	0.04	0.190	0.6	480	30000	22.0	4800	0.5	230000	2.0	0.7	14.0	120.0	1200.0	110000
5	11	0.05	0.180	0.8	350	22000	7.0	5000	0.5	260000	0.9	1.0	7.0	86.0	1200.0	63000
5	11	0.40	0.200	0.7	410	26000	16.0	5100	0.5	240000	2.0	0.5	12.0	97.0	1300.0	130000
5	12	0.04	0.550	0.4	330	29000	9.0	5500	0.5	240000	0.8	0.6	12.0	69.0	1600.0	120000
5	12	0.05	0.450	0.4	370	30000	6.0	7800	0.5	250000	0.8	0.7	13.0	140.0	1600.0	140000
5	12	0.08	0.250	0.7	270	23000	11.0	6200	0.5	290000	1.0	0.5	10.0	110.0	440.0	120000
5	13	0.04	0.250	0.3	380	45000	12.0	7300	0.5	270000	1.0	0.6	20.0	180.0	1400.0	130000
5	13	0.06	0.400	0.3	340	26000	9.0	6200	0.5	250000	1.0	0.5	10.0	110.0	1400.0	90000
5	13	0.04	0.350	0.3	340	26000	14.0	6800	0.5	250000	2.0	0.9	13.0	110.0	1500.0	86000
5	14	0.05	0.300	0.7	380	45000	18.0	6000	0.5	270000	1.0	0.5	14.0	140.0	1700.0	120000
5	14	0.02	0.250	0.2	390	32000	8.0	6200	0.5	260000	1.0	0.5	9.0	190.0	1200.0	110000
5	14	0.03	0.300	0.4	360	30000	11.0	6700	0.5	230000	0.7	0.6	12.0	89.0	1100.0	110000
5	15	0.03	0.170	0.8	620	33000	10.0	5700	0.5	240000	0.9	0.5	14.0	160.0	1400.0	130000
5	15	0.06	0.300	1.4	880	36000	9.0	6600	0.5	250000	0.8	0.8	11.0	120.0	1600.0	65000
5	15	0.04	0.250	0.9	370	26000	11.0	7000	0.5	240000	2.0	0.6	13.0	100.0	1300.0	98000
5	16	0.35	0.950	43.0	220	19000	11.0	7600	0.5	240000	0.9	0.5	12.0	91.0	1600.0	82000
5	17	0.03	0.500	0.7	300	31000	9.0	4100	0.5	180000	0.8	2.0	6.0	180.0	1600.0	56000
5	17	0.03	0.500	1.6	640	36000	19.0	6100	0.5	210000	1.0	0.7	13.0	200.0	2200.0	110000
5	17	0.05	0.400	2.1	400	34000	9.0	5000	0.5	170000	0.7	2.0	8.0	130.0	2000.0	93000
5	18	0.06	10.000	5.3	270	33000	13.0	3600	0.5	180000	0.8	5.0	7.0	130.0	1100.0	99000
5	18	0.04	3.500	1.4	260	36000	14.0	4900	0.5	190000	0.7	3.0	5.0	160.0	1100.0	64000
5	18	0.03	1.800	1.0	330	38000	9.0	4700	0.5	210000	0.6	16.0	4.0	120.0	1100.0	90000
5	19	0.05	0.450	0.3	240	38000	2.0	3300	0.5	200000	0.5	1.0	3.0	110.0	800.0	61000
5	19	0.03	0.350	0.2	260	24000	8.0	3000	0.5	200000	0.5	0.8	5.0	100.0	760.0	85000

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	PB210	RA226	URAN	BORON	PHOSPH	SILV	ALUMIN	BER	CALCIUM	CADM	COB	CHROM	COPP	IRON	POTASS
5	19	0.04	0.350	0.2	490	33000	17.0	5700	0.5	230000	0.5	2.0	7.0	190.0	1400.0	110000
5	20	0.05	0.400	0.2	310	34000	8.0	3200	0.5	220000	0.5	0.5	6.0	130.0	880.0	100000
5	20	0.07	0.300	0.4	220	38000	10.0	4500	0.5	230000	0.5	0.7	7.0	160.0	1100.0	79000
5	20	0.09	0.450	0.4	190	28000	6.0	3400	0.5	210000	0.8	2.0	4.0	110.0	890.0	74000
5	21	0.04	0.950	0.4	260	35000	10.0	4200	0.5	210000	0.8	0.6	4.0	110.0	800.0	89000
5	21	0.05	1.000	0.2	300	28000	9.0	3500	0.5	160000	1.0	1.0	8.0	110.0	680.0	78000
5	21	0.04	0.500	0.2	290	28000	8.0	3700	0.5	200000	0.7	0.5	5.0	130.0	680.0	55000
5	22	0.05	0.450	0.4	345	33000	9.0	5200	0.5	190000	0.8	2.0	6.0	110.0	1150.0	99500
5	22	0.05	0.200	0.2	390	40000	14.0	4100	0.5	190000	0.6	0.6	8.5	205.0	1300.0	105000
5	22	0.04	0.500	0.3	270	29000	8.0	4100	0.5	190000	0.7	0.5	8.0	140.0	400.0	130000
6	1	0.03	0.060	2.6	390	50400	6.0	1600	0.5	198000	1.0	1.3	12.0	100.0	700.0	88000
6	1	0.03	0.050	5.4	300	49600	1.6	1700	0.5	191000	0.7	0.5	12.0	87.0	600.0	137000
6	1	0.03	0.080	6.5	410	48700	5.8	1600	1.0	182000	1.4	1.0	16.0	110.0	1100.0	182000
6	2	0.10	0.090	10.0	210	46700	0.5	2800	0.5	190000	0.5	0.5	13.0	73.0	1500.0	188000
6	2	0.07	0.050	8.5	180	35800	1.8	2000	1.0	209000	1.0	1.0	9.9	73.0	1200.0	173000
6	2	0.06	0.080	11.0	180	37200	2.4	2000	1.0	202000	1.0	1.0	8.0	67.0	1200.0	188000
6	5	<0.02	0.070	0.7	140	42000	2.3	1800	0.5	200000	0.5	0.9	6.6	60.0	700.0	110000
6	5	<0.02	0.010	1.0	120	31000	1.9	3500	0.5	240000	0.5	0.5	8.9	49.0	830.0	156000
6	5	<0.02	0.160	0.4	110	44500	4.7	2300	0.5	266000	0.7	1.0	19.0	72.0	1400.0	147000
6	6	0.02	0.120	0.2	74	58900	2.8	2500	0.5	204000	0.7	1.4	19.0	66.0	1200.0	149000
6	6	<0.02	0.130	0.4	78	55000	0.7	3400	0.5	210000	0.5	0.5	8.5	50.0	910.0	110000
6	6	0.02	0.130	0.2	73	56300	4.2	2300	0.5	225000	0.5	1.3	17.0	78.0	1800.0	145000
6	7	0.02	0.110	1.8	76	54800	2.7	2300	0.5	222000	0.5	0.5	8.0	56.0	880.0	143000
6	7	0.02	0.120	4.3	140	49200	6.9	1800	0.5	256000	0.5	0.6	12.0	62.0	1400.0	145000
6	7	<0.02	0.100	3.5	65	33000	1.5	2600	0.5	120000	0.5	0.5	3.7	32.0	520.0	100000
6	8	0.02	0.090	0.2	400	42000	16.0	1700	0.5	220000	0.5	0.9	5.6	46.0	840.0	90000
6	8	<0.02	0.100	0.2	230	43800	6.6	2200	0.5	207000	0.5	1.2	15.0	60.0	1500.0	163000
6	8	0.03	0.110	0.2	280	40000	3.0	2700	0.5	260000	0.5	0.8	9.1	31.0	1100.0	120000
6	9	<0.02	0.110	0.4	94	41000	2.0	2300	0.5	220000	0.5	0.5	5.5	43.0	720.0	110000
6	9	0.03	0.110	0.3	170	47000	1.9	2500	0.5	240000	0.5	0.5	7.4	49.0	860.0	120000
6	9	<0.02	0.100	0.4	150	47800	2.2	3200	0.5	218000	0.5	0.5	13.0	60.0	1000.0	175000
6	10	0.02	0.050	0.4	310	42900	13.0	1800	0.5	235000	0.8	0.5	14.0	57.0	1600.0	154000
6	10	0.02	0.060	0.2	150	35900	8.3	2100	0.5	219000	0.5	2.1	10.0	59.0	1400.0	162000
6	10	0.02	0.020	0.2	320	45000	3.3	2500	0.5	170000	0.5	0.5	7.2	48.0	950.0	110000
6	11	<0.02	0.090	0.2	330	35000	4.3	2200	0.5	228000	0.5	0.5	7.9	53.0	1200.0	131000
6	11	<0.02	0.060	0.2	420	39000	4.3	4000	0.5	260000	0.5	0.5	8.8	58.0	1700.0	89000
6	11	0.02	0.030	0.2	860	36000	5.6	2100	0.5	230000	0.8	0.5	7.6	37.0	930.0	94000
6	13	0.02	0.040	0.2	380	37000	5.4	1500	0.5	260000	0.5	0.5	7.0	42.0	680.0	97000
6	13	<0.02	0.060	0.2	550	39700	5.8	1800	0.5	212000	0.5	1.3	7.5	46.0	590.0	131000
6	13	0.02	0.070	0.2	470	28400	7.6	1100	0.5	246000	0.5	0.5	11.0	48.0	1300.0	123000
6	14	<0.02	0.040	0.2	340	37900	6.0	1200	0.5	242000	0.5	0.5	6.1	48.0	680.0	124000
6	14	0.02	0.050	0.3	310	36000	4.3	1400	0.5	240000	0.6	0.5	8.1	50.0	730.0	110000
6	14	<0.02	0.070	0.2	340	39000	3.9	3500	0.5	250000	0.5	0.5	7.0	54.0	820.0	100000
6	17	0.03	0.250	1.0	240	37000	4.0	3400	0.5	170000	0.5	5.0	10.0	110.0	1500.0	94000
6	17	0.06	0.700	0.5	180	42000	6.0	3400	0.5	170000	0.5	4.0	9.0	95.0	1100.0	91000
6	17	0.10	0.800	0.4	130	27000	7.0	1600	0.5	300000	0.5	1.5	3.0	89.0	1200.0	98000
6	18	0.08	3.500	1.1	450	41000	5.0	2300	0.5	200000	0.5	6.0	8.0	74.0	1300.0	100000
6	18	0.06	0.850	1.0	180	34000	9.0	2700	0.5	200000	0.9	16.0	9.0	100.0	1400.0	94000
6	18	0.10	0.350	0.2	110	58000	8.0	3400	0.5	240000	0.5	10.0	3.0	94.0	700.0	71000
6	19	0.11	0.080	0.6	150	43000	6.0	1100	0.5	290000	0.5	1.0	3.0	48.0	740.0	69000
6	19	0.04	0.130	0.1	140	43000	7.0	1800	0.5	280000	0.5	0.7	6.0	82.0	2200.0	87000
6	19	0.03	0.110	0.1	275	41000	9.0	1100	0.5	270000	0.5	1.0	5.0	240.0	890.0	86000
6	20	0.06	0.100	0.1	280	34000	6.0	1100	0.5	260000	0.5	0.5	6.0	70.0	1600.0	92000
6	20	0.06	0.070	0.1	99	40000	6.0	1900	0.5	250000	2.0	2.0	6.0	77.0	800.0	87000
6	20	0.06	0.060	0.2	110	46000	4.0	2100	0.5	300000	0.7	2.0	5.0	100.0	760.0	82000

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	RA210	RA226	URAN	BORON	PHOSPH	SILV	ALUMIN	BER	CALCIUM	CADM	COB	CHROM	COPP	IRON	POTASS
6	21	0.05	0.350	0.2	240	30000	5.0	1400	0.5	200000	0.5	0.6	2.0	64.0	93.0	94000
6	21	0.04	0.120	0.4	340	34000	10.0	1300	0.5	210000	0.5	0.7	4.0	95.0	970.0	96000
6	21	0.03	0.100	0.2	280	38000	8.0	1300	0.5	180000	0.5	0.7	5.0	74.0	910.0	89000
6	22	0.08	0.120	0.1	200	41500	10.5	1700	0.5	210000	0.5	1.0	3.5	61.5	1300.0	89000
6	22	0.03	0.050	0.1	360	41000	12.5	1200	0.5	220000	0.5	0.5	4.5	140.0	760.0	94500
6	22	0.07	0.080	0.2	500	51000	16.0	1900	0.5	200000	0.5	0.5	7.0	170.0	1200.0	93000
7	5	0.25	0.300	60.0	32	44300	0.5	20500	5.8	58900	13.0	14.0	54.0	59.0	19600.0	128000
7	5	0.30	1.100	58.0	27	46500	0.5	23700	5.9	58600	11.0	13.0	55.0	29.0	19900.0	139000
7	5	0.45	0.400	73.0	21	50000	0.5	26000	5.6	70000	12.0	10.0	37.0	81.0	17000.0	180000
7	6	0.24	1.000	24.0	28	21000	0.5	18000	2.3	48000	7.9	5.5	26.0	41.0	11000.0	150000
7	6	0.25	0.500	23.0	34	55000	0.5	18000	2.7	58000	9.4	6.2	29.0	72.0	13000.0	150000
7	6	0.30	0.350	22.0	20	59800	0.5	22000	5.0	50300	19.0	10.0	52.0	63.0	17800.0	115000
7	7	.	1.700	380.0	35	43000	0.5	20000	3.1	40000	9.7	7.1	32.0	70.0	14000.0	130000
7	7	0.40	1.500	378.0	23	43900	0.5	23400	6.0	42800	23.0	13.0	48.0	91.0	20200.0	84600
7	7	0.30	1.400	446.0	42	43000	0.5	24000	3.5	46000	7.6	8.1	41.0	97.0	15000.0	130000
7	8	0.30	0.700	11.0	34	53000	0.5	26000	5.0	65000	11.0	9.0	33.0	69.0	16000.0	65000
7	8	0.35	0.550	12.0	38	43000	0.5	25000	3.3	56000	8.8	7.6	32.0	83.0	15000.0	130000
7	8	0.30	1.500	13.0	34	37700	0.5	22900	4.7	52900	13.0	10.0	35.0	87.0	17300.0	99200
7	10	0.25	0.250	21.0	35	40700	0.5	27300	6.3	45400	15.0	12.0	57.0	54.0	22500.0	93600
7	10	0.25	0.350	17.0	28	40000	0.5	25000	3.3	49000	7.5	8.5	34.0	38.0	16000.0	100000
7	10	0.25	0.300	21.0	63	37000	0.5	23000	3.3	48000	7.9	8.6	33.0	75.0	15000.0	116000
7	21	0.20	1.600	2.2	84	71000	5.0	13000	1.0	110000	9.0	4.0	20.0	130.0	7100.0	230000
7	21	0.20	0.650	1.4	49	78000	5.0	14000	1.0	87000	7.0	3.0	20.0	140.0	7400.0	250000
7	21	0.25	2.300	1.2	100	79000	5.0	10000	1.0	85000	7.0	4.0	18.0	130.0	6300.0	250000
7	22	0.25	0.800	2.2	63	59000	5.0	14000	2.0	61000	7.0	8.0	30.0	120.0	14000.0	200000
7	22	0.20	0.650	1.9	68	74000	5.0	16000	1.0	80000	6.0	7.0	29.0	100.0	11000.0	230000
7	22	0.17	1.600	1.7	70	72000	0.8	14000	0.5	62000	5.0	2.0	9.0	110.0	8200.0	98000
8	1	0.30	0.250	196.0	40	49500	1.0	23000	2.4	54000	9.0	5.6	35.0	59.0	12100.0	141000
8	1	0.35	0.600	242.0	34	48300	1.0	26200	3.0	51000	8.8	6.4	37.0	60.0	13500.0	130000
8	1	0.35	0.600	221.0	60	62900	1.0	19500	2.2	52000	10.0	5.4	38.0	60.0	10900.0	176000
8	2	0.45	0.900	333.0	19	43200	0.5	28000	3.2	46000	9.8	7.8	39.0	55.0	18700.0	128000
8	2	0.45	0.900	321.0	26	48100	1.0	24900	3.0	47000	12.0	8.0	42.0	56.0	13700.0	156000
8	2	0.40	1.000	339.0	39	40600	1.0	26500	3.2	47000	10.0	7.6	36.0	54.0	15600.0	134000
8	5	0.35	0.700	57.0	13	41000	0.5	25000	3.2	60000	8.6	7.5	38.0	51.0	15000.0	120000
8	5	0.55	0.500	80.0	25	35200	0.5	31600	5.0	49600	14.0	10.0	48.0	62.0	19200.0	95800
8	5	0.35	1.200	69.0	13	40700	0.5	26100	4.5	53000	14.0	9.9	35.0	75.0	16500.0	104000
8	10	0.18	0.200	18.0	5	30000	0.5	34000	9.3	43000	24.0	10.0	43.0	48.0	22000.0	88000
8	10	0.35	0.800	16.5	21	32000	0.5	29300	4.8	39100	6.1	8.1	38.0	51.0	18850.0	85600
8	10	0.35	0.300	17.0	21	32000	0.5	33000	6.1	47000	8.8	8.9	35.0	53.0	20000.0	52000
8	11	0.45	0.400	14.0	30	39000	0.5	32000	6.3	50000	5.4	9.3	54.0	46.0	21000.0	62000
8	11	0.35	1.100	15.0	35	33300	0.5	30300	4.9	39500	5.2	9.4	79.0	43.0	19500.0	94400
8	11	0.30	0.200	14.0	38	36000	0.5	26000	3.2	47000	5.2	7.1	42.0	39.0	15000.0	100000
8	12	0.25	0.300	6.5	18	43000	0.5	34000	5.7	49000	11.0	8.4	46.0	64.0	18000.0	110000
8	12	0.25	0.500	7.7	31	41000	0.5	30000	5.9	53000	4.9	9.1	50.0	48.0	19000.0	70000
8	12	0.30	0.200	8.1	32	31000	0.5	27000	3.2	78000	2.8	7.2	37.0	35.0	16000.0	89000
8	13	0.35	0.140	5.6	29	44000	0.5	21000	2.9	46000	5.9	6.5	32.0	42.0	14000.0	97000
8	13	0.30	0.350	6.3	32	51000	0.5	32000	6.3	52000	8.4	9.4	47.0	52.0	20000.0	100000
8	13	0.30	0.200	5.7	26	40000	0.5	23000	3.1	43000	6.1	7.1	34.0	47.0	15000.0	110000
8	14	0.31	0.900	10.0	25	47200	0.5	29600	4.4	46900	6.5	7.8	45.0	48.0	18000.0	98500
8	14	0.40	1.500	17.0	18	37400	0.5	31000	5.3	39700	5.8	9.8	41.0	40.0	20200.0	99000
8	14	0.40	0.300	15.0	60	34000	0.5	29000	3.6	40000	5.0	7.8	33.0	46.0	17000.0	96000
8	15	0.35	1.400	48.0	35	46300	0.5	24700	4.4	43700	8.7	9.2	45.0	71.0	16800.0	103000
8	15	0.35	1.800	47.0	16	42200	0.5	25000	4.2	42400	8.5	8.1	44.0	63.0	16500.0	98200
8	15	0.30	0.900	54.0	26	49000	0.5	33000	6.0	50000	30.0	10.0	40.0	79.0	19000.0	56000
8	16	0.45	5.500	712.0	17	20000	0.5	25000	3.2	19000	2.3	5.4	31.0	31.0	16000.0	66000

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	PB210	RA226	URAN	BORON	PHOSPH	SILV	ALUMIN	BER	CALCIUM	CADM	COB	CHROM	COPP	IRON	POTASS
8	16	0.35	6.000	821.0	16	25000	15.0	28000	3.4	30000	3.0	5.8	30.0	39.0	16000.0	78000
8	16	0.60	12.000	1270.0	19	26000	0.5	26000	3.2	30000	2.0	6.0	31.0	42.0	15000.0	76000
8	17	0.25	2.200	10.5	24	28500	0.5	23500	4.0	36000	3.0	8.0	31.0	33.5	16500.0	76000
8	17	0.35	0.850	11.0	28	29000	0.5	23000	4.0	55000	2.0	3.0	15.0	34.0	15000.0	78000
8	17	0.35	0.550	11.0	23	27000	5.0	21000	2.0	71000	4.0	8.0	32.0	39.0	18000.0	96000
8	18	1.10	5.500	40.0	65	35000	0.5	25000	5.0	36000	5.0	6.0	22.0	56.0	16500.0	94000
8	18	0.40	1.100	35.0	41	33000	0.5	24000	5.0	53000	4.0	13.0	47.0	70.0	17000.0	120000
8	18	0.35	1.700	36.0	40	49000	5.0	25000	5.0	48000	5.0	27.0	48.0	59.0	20000.0	160000
8	19	0.30	0.550	2.6	16	58000	5.0	22000	2.0	86000	10.0	7.0	30.0	81.0	15000.0	160000
8	19	0.30	1.600	2.8	29	51000	5.0	24000	3.0	70000	7.0	9.0	32.0	61.0	16000.0	150000
8	19	0.35	0.500	3.0	24	51000	5.0	25000	2.0	72000	10.0	8.0	35.0	76.0	16000.0	140000
8	20	0.35	0.600	4.9	29	57000	5.0	18000	2.0	72000	15.0	7.0	33.0	100.0	13000.0	170000
8	20	0.30	0.300	3.7	34	62000	5.0	20000	2.0	73000	7.0	8.0	33.0	55.0	14000.0	160000
8	20	0.30	0.450	3.3	18	56000	5.0	22000	2.0	68000	12.0	9.0	34.0	86.0	15000.0	160000
9	1	0.45	0.200	98.0	46	42400	1.1	11300	1.7	92000	12.0	6.4	30.0	110.0	7800.0	126000
9	1	0.40	0.200	85.0	38	48800	0.5	10300	1.7	86000	8.2	4.0	29.0	110.0	8100.0	180000
9	1	0.45	0.250	96.0	40	45900	0.5	11000	1.3	101000	6.7	2.6	19.0	95.0	6400.0	158000
9	2	0.90	0.450	152.0	58	34500	1.5	15900	2.0	89000	6.7	5.5	25.0	120.0	9800.0	201000
9	2	0.60	0.350	164.0	100	28500	0.8	14800	2.6	86000	7.5	5.8	27.0	120.0	10400.0	148000
9	2	0.50	0.500	177.0	45	32600	0.6	15100	2.2	87000	7.2	4.2	14.0	120.0	8300.0	193000
10	1	0.50	0.400	287.0	12	32000	<0.2	34000	5.5	34000	14.0	8.1	42.0	72.0	13000.0	56000
10	1	0.50	0.550	307.0	31	36000	<0.2	32000	5.6	36000	14.0	8.0	52.0	77.0	17000.0	50000
10	1	0.40	0.400	287.0	22	47000	0.8	27000	4.4	39000	14.0	8.2	39.0	79.0	7200.0	56000
10	2	0.50	0.600	353.0	39	30000	0.2	27000	5.4	33000	16.0	8.4	54.0	92.0	16000.0	110000
10	2	0.50	0.650	351.0	19	29000	<0.2	34000	6.6	32000	12.0	11.0	280.0	75.0	19000.0	74000
10	2	0.50	0.650	347.0	15	32000	<0.2	33000	6.1	37000	16.0	9.8	45.0	78.0	13000.0	51000
10	5	0.35	1.200	64.0	28	31800	0.5	29200	4.6	35900	15.0	8.7	45.0	59.0	19100.0	80500
10	5	0.35	0.700	64.0	18	32000	0.5	34000	6.6	41000	16.0	10.0	41.0	58.0	21000.0	47000
10	5	0.40	1.000	62.0	21	27600	0.5	32300	6.4	34400	22.0	11.0	60.0	65.0	24600.0	79000
10	6	0.50	0.600	22.0	11	36000	0.5	35000	6.3	42000	12.0	9.1	48.0	58.0	21000.0	76000
10	6	0.70	0.550	27.0	10	23000	0.5	31000	4.2	24000	10.0	8.5	38.0	50.0	20000.0	59000
10	6	0.50	0.200	21.0	18	29000	0.5	30000	4.0	33000	9.0	7.6	39.0	50.0	19000.0	82000
10	7	0.60	1.200	374.0	26	23000	3.9	34000	4.2	27000	8.4	8.5	44.5	53.5	20000.0	62000
10	7	0.50	1.700	453.0	19	30000	0.5	37000	6.6	34000	12.0	9.4	37.0	63.0	21000.0	47000
10	7	0.55	1.400	444.0	12	23200	0.5	36900	7.6	28000	14.0	13.0	54.0	60.0	27600.0	62600
10	8	0.45	0.400	11.0	16	20000	0.5	31000	6.6	29000	9.6	10.0	40.0	51.0	22000.0	37000
10	8	0.45	0.500	11.0	22	27000	0.5	38000	7.0	38000	9.6	11.0	54.0	52.0	23000.0	38000
10	8	0.35	0.700	9.6	21	24800	0.5	30900	5.1	32000	8.6	9.2	40.0	52.0	20800.0	64700
10	9	0.40	0.400	29.0	17	35000	0.5	39000	6.6	35000	8.6	9.1	39.0	61.0	21000.0	95000
10	9	0.40	0.600	29.0	6	27600	0.5	36800	7.1	29000	14.0	11.0	54.0	54.0	26000.0	74300
10	9	0.30	0.550	29.0	16	31500	0.5	33600	6.6	33600	15.0	10.0	50.0	52.0	24300.0	85100
10	10	0.40	0.290	16.5	184	23000	0.5	30500	4.2	26500	6.9	8.3	36.0	44.0	20000.0	66000
10	10	0.30	0.450	15.0	5	26000	0.5	32000	3.9	29000	7.1	7.9	34.0	41.0	19000.0	69000
10	10	0.55	0.200	16.0	16	29000	0.5	34000	7.0	36000	9.3	10.0	46.0	48.0	23000.0	36000
10	15	0.40	0.800	44.0	31	36000	0.5	34000	6.8	35000	8.7	10.0	44.0	78.0	22000.0	91000
10	15	0.35	0.800	42.0	27	36700	0.5	29500	4.7	33600	6.0	9.6	41.0	43.0	19100.0	123000
10	15	0.55	1.000	42.0	14	22700	0.5	25400	3.8	22600	4.4	7.6	32.0	39.0	16100.0	78400
10	21	0.25	2.600	2.3	52	70000	5.0	15000	1.0	82000	8.0	5.0	32.0	79.0	11000.0	230000
10	21	0.25	4.000	1.8	30	77000	5.0	13000	1.0	90000	9.0	9.0	24.0	82.0	9300.0	230000
10	21	0.25	3.700	2.1	65	76000	5.0	16000	1.0	79000	8.0	7.0	28.0	100.0	11000.0	230000
10	22	0.25	1.000	2.8	28	60000	5.0	25000	2.0	63000	6.0	9.0	31.0	39.0	14000.0	160000
10	22	0.25	1.300	2.8	52	63000	5.0	18000	2.0	62000	7.0	6.0	29.0	52.0	13000.0	170000
10	22	0.20	1.200	2.5	37	59000	5.0	17000	2.0	58000	6.0	7.0	31.0	57.0	14000.0	190000
11	5	0.09	0.070	5.0	410	62100	2.5	3400	0.8	218000	19.0	5.6	15.0	310.0	2600.0	140000
11	6	0.10	0.800	1.3	210	60400	0.9	2300	0.5	207000	18.0	8.1	9.6	260.0	1700.0	150000

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	PB210	RA226	URAN	BORON	PHOSPH	SILV	ALUMIN	BER	CALCIUM	CADM	COB	CHROM	COPP	IRON	POTASS
11	7	0.08	0.800	21.0	430	55400	3.4	2700	0.5	211000	26.0	6.9	13.0	300.0	2400.0	118000
11	17	0.03	0.650	1.1	630	56000	4.0	1700	0.5	220000	39.0	18.0	8.0	240.0	2200.0	88000
11	17	0.05	2.000	0.7	540	29000	4.0	960	0.5	28000	39.0	8.0	4.0	220.0	1200.0	11000
11	17	0.08	2.500	7.6	370	42000	2.0	1000	0.5	290000	23.0	6.0	6.0	210.0	1300.0	62000
11	18	0.40	30.000	4.5	630	50000	9.0	2300	0.5	190000	26.0	47.0	8.0	400.0	2500.0	94000
11	18	0.17	16.000	4.5	1900	38000	2.0	3000	2.0	220000	7.0	29.0	9.0	380.0	2000.0	89000
11	18	0.06	4.000	3.7	740	53000	10.0	2400	0.5	220000	18.0	62.0	7.0	380.0	2400.0	89000
11	19	0.06	0.650	0.5	580	49000	2.0	1700	0.5	180000	10.0	7.0	7.0	290.0	1800.0	89000
11	19	0.10	0.600	0.6	510	70000	2.0	2100	0.5	230000	12.0	5.0	4.0	290.0	2100.0	80000
11	19	0.06	1.100	0.2	690	51000	2.0	1600	0.5	200000	15.0	9.0	5.0	320.0	1900.0	70000
11	20	0.10	0.550	0.5	580	39000	3.0	2000	0.5	255000	17.0	11.0	8.0	250.0	2000.0	60000
11	20	0.14	0.900	0.8	590	48000	3.0	2200	0.5	230000	26.0	17.0	10.0	280.0	2000.0	74000
11	20	0.09	0.400	0.5	480	42000	2.0	1300	0.5	210000	28.0	24.0	6.0	340.0	1500.0	52000
11	21	0.09	2.500	0.4	620	54000	6.0	850	0.5	260000	34.0	22.0	6.0	320.0	1600.0	93000
11	21	0.06	0.750	0.5	530	53000	4.0	610	0.5	310000	41.0	20.0	4.0	280.0	1300.0	82000
11	21	0.07	0.750	0.4	390	36000	3.0	780	0.5	250000	29.0	11.0	3.0	240.0	1100.0	65000
11	22	0.06	2.000	0.4	470	75500	1.0	2000	0.5	180000	18.0	13.0	5.0	350.0	1600.0	100000
11	22	0.08	0.600	0.7	780	76000	3.0	2100	0.5	190000	13.0	4.0	5.0	320.0	2200.0	94000
11	22	0.16	0.700	0.7	630	75000	4.0	3000	0.5	210000	16.0	11.0	6.0	370.0	3000.0	140000
12	6	0.90	0.400	25.0	49	45000	0.5	24000	5.2	47000	18.0	7.9	40.0	110.0	17000.0	85000
12	6	0.25	0.600	19.0	64	41600	0.5	25500	4.4	27600	17.0	7.6	43.0	110.0	17000.0	96000
12	6	0.30	0.200	19.0	34	36500	0.5	24300	6.6	29600	23.0	10.0	53.0	77.0	24100.0	101000
12	7	0.30	6.000	215.0	41	38000	0.5	22000	3.0	32000	9.3	6.7	52.0	77.0	14000.0	130000
12	7	0.35	1.900	325.0	49	50000	0.5	24000	3.5	27000	10.0	6.8	32.0	87.0	17000.0	120000
12	7	0.30	1.100	208.0	44	39900	0.5	24000	5.5	31100	15.0	9.7	51.0	120.0	20100.0	111000
12	8	0.30	0.400	8.8	72	32600	0.5	23500	6.0	32800	24.0	8.7	66.0	90.0	22300.0	88000
12	8	0.30	0.500	8.4	46	44300	0.5	26500	6.1	31900	21.0	8.9	51.0	100.0	22400.0	106000
12	8	0.30	0.180	8.1	53	37000	0.5	23500	5.7	31200	21.0	10.0	55.0	82.0	21400.0	114000
12	9	0.55	0.450	25.0	47	34700	0.5	26000	6.8	24700	13.0	11.0	60.0	100.0	24000.0	106000
12	9	0.17	0.250	19.0	36	43700	0.5	23200	3.8	25400	10.0	6.0	39.0	140.0	15700.0	117000
12	9	0.40	0.200	19.0	57	39000	0.5	34000	7.1	33000	10.0	10.0	46.0	130.0	22000.0	130000
13	8	0.08	0.350	0.6	580	37000	3.0	4800	0.9	210000	0.9	2.0	20.0	160.0	3900.0	97000
13	8	0.07	0.300	1.3	510	33000	0.7	4900	0.9	170000	1.0	2.0	8.0	160.0	2900.0	90000
13	8	0.17	0.500	0.9	450	34000	2.0	5800	0.8	220000	1.0	2.0	9.0	170.0	2700.0	64000
13	9	0.10	0.400	5.0	490	32000	2.0	5800	0.9	220000	1.0	2.0	8.0	140.0	3000.0	50000
13	9	0.11	0.500	4.7	420	39000	2.0	5500	0.9	210000	0.7	1.0	10.0	200.0	2700.0	83000
13	9	0.16	0.350	3.8	350	31000	2.0	5600	1.0	230000	1.0	4.0	11.0	150.0	3800.0	95000
13	21	0.04	1.550	0.2	415	36000	7.0	1600	0.5	230000	0.5	2.0	2.5	205.0	840.0	97000
13	21	0.03	0.780	0.2	365	31000	4.0	1180	0.5	245000	0.5	2.0	6.5	140.0	750.0	92000
13	21	0.03	0.950	0.6	310	35500	3.0	980	0.5	215000	0.5	1.2	5.0	170.0	780.0	98500
13	22	0.05	0.280	0.4	545	42500	3.5	2200	0.5	175000	0.5	1.5	5.0	170.0	1350.0	96000
13	22	0.06	0.330	0.4	415	40500	3.5	3200	0.5	173000	0.5	1.0	4.5	155.0	1500.0	111500
13	22	0.10	0.550	0.3	470	38000	5.0	4500	1.0	180000	1.0	3.0	14.0	160.0	2400.0	160000
14	9	0.60	1.900	44.0	14	27000	0.5	24000	3.2	130000	9.0	9.6	30.0	45.0	11000.0	120000
14	9	0.45	0.300	37.0	9	24900	0.5	25100	6.0	100000	19.0	14.0	47.0	45.0	17100.0	110000
14	9	0.55	0.400	36.0	19	24000	0.7	28000	5.4	136000	12.0	13.0	38.0	55.0	13000.0	89000
15	11	0.05	0.250	0.5	170	34900	0.5	1400	0.5	296000	6.3	0.6	18.0	97.0	310.0	126000
15	11	0.05	0.180	0.2	410	25900	0.5	1000	0.5	272000	7.2	7.7	5.9	140.0	580.0	116000
15	11	0.07	0.190	0.3	360	20200	1.1	1300	0.5	303000	9.4	5.4	5.7	98.0	660.0	91700
16	16	0.07	0.700	32.0	210	25700	0.5	3600	0.6	312000	0.5	0.8	6.3	67.0	1600.0	113000
16	16	0.03	0.500	27.0	160	32600	0.5	4000	1.1	279000	0.5	2.3	12.0	85.0	1400.0	156000
16	16	0.06	1.000	46.0	240	36700	1.6	3600	0.8	262000	0.5	2.7	9.3	52.0	1700.0	142000
16	17	0.04	0.700	1.3	250	26000	0.5	4200	0.9	200000	0.5	1.0	4.0	91.0	2300.0	65000
16	17	0.06	7.000	2.7	240	28000	0.5	2300	0.5	220000	0.5	0.9	2.0	100.0	1300.0	87000
20	22	0.07	0.450	0.3	380	58000	4.0	3200	0.5	140000	56.0	3.0	4.0	240.0	1500.0	92000

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	PB210	RA226	URAN	BORON	PHOSPH	SILV	ALUMIN	BER	CALCIUM	CADM	COB	CHROM	COPP	IRON	POTASS
20	22	0.14	0.650	0.2	380	54000	2.0	3500	0.5	170000	54.0	2.0	5.0	230.0	540.0	170000
20	22	0.07	0.400	0.2	440	54000	5.0	2800	0.5	140000	49.0	2.0	5.0	260.0	1300.0	110000
21	17	0.02	0.140	0.3	350	27000	2.0	1100	0.5	240000	0.8	4.0	3.0	72.0	910.0	78000
21	17	0.09	0.750	0.5	260	20000	0.5	890	0.5	240000	0.7	2.0	5.0	64.0	950.0	80000
21	17	0.08	0.650	0.9	280	20000	1.0	790	0.5	260000	1.0	1.0	12.0	55.0	830.0	78000
22	1	<0.02	0.030	0.8	5	100	0.5	3100	0.9	<2	0.5	0.7	68.0	2.0	3400.0	1000
22	1	<0.02	0.030	0.8	5	100	0.5	3900	0.8	<2	0.5	0.9	57.0	1.0	2800.0	1000
22	1	0.03	0.070	1.1	5	200	0.5	9100	1.9	<2	0.5	1.8	41.0	1.0	6400.0	1000
22	1	0.07	0.030	1.1	6	40	0.5	3600	1.2	180	0.5	0.8	250.0	2.4	3800.0	590
22	1	0.04	0.030	0.7	10	40	0.5	3900	0.9	190	0.5	0.6	140.0	1.8	2600.0	660
22	1	0.02	0.020	0.7	7	40	0.5	4100	1.2	180	0.5	0.8	210.0	2.1	3300.0	710
22	2	<0.02	0.080	1.9	5	300	0.5	11000	2.9	1000	0.5	2.4	12.0	1.0	11000.0	1000
22	2	<0.02	0.060	1.8	5	100	0.5	9100	1.9	1000	0.5	1.7	14.0	1.0	6500.0	1000
22	2	<0.02	0.050	1.8	5	200	0.5	5700	1.0	1000	0.5	2.1	9.9	2.0	3400.0	<10
22	2	0.14	0.080	1.3	94	600	0.5	6100	2.0	1300	0.5	2.2	340.0	9.9	5500.0	990
22	2	0.17	0.040	1.7	64	410	0.5	5700	2.0	840	0.5	2.0	370.0	7.0	6100.0	990
22	2	0.06	0.080	1.5	58	440	0.5	6800	2.4	950	0.5	2.1	430.0	8.9	6300.0	820
22	5	0.20	0.050	1.3	82	840	0.5	6500	2.1	1600	0.5	2.5	250.0	33.0	5100.0	930
22	5	0.15	0.060	1.5	79	370	0.5	5800	2.7	1200	0.5	2.9	450.0	17.0	7200.0	1000
22	5	0.18	0.060	1.7	90	700	0.5	7700	2.5	1000	0.5	3.1	300.0	61.0	6200.0	1200
22	6	0.06	0.020	0.9	64	220	0.5	5600	2.1	650	0.5	1.8	300.0	5.6	5600.0	1400
22	6	0.07	0.030	0.9	100	260	0.5	4600	2.2	690	0.5	1.7	330.0	4.2	6200.0	1300
22	6	0.15	0.040	0.8	83	460	0.5	5300	2.2	580	0.5	1.9	400.0	8.8	6300.0	1000
22	7	0.05	0.060	2.1	5	340	0.5	9200	3.4	740	0.5	2.7	180.0	3.6	8600.0	1200
22	7	0.04	0.050	2.1	5	200	0.5	7100	2.2	470	0.5	3.2	160.0	3.9	6100.0	1000
22	7	0.65	0.050	2.0	5	230	0.5	7400	2.4	650	0.5	2.0	150.0	4.1	6500.0	1500
22	8	0.04	0.030	1.2	100	190	0.5	6500	2.3	880	0.5	2.1	220.0	3.3	7400.0	1600
22	8	0.04	0.010	0.9	8	60	0.5	4100	1.4	370	0.5	1.4	270.0	2.3	4400.0	1600
22	8	0.04	0.030	1.4	8	300	0.5	7500	2.2	690	0.5	1.7	190.0	2.4	6800.0	1400
22	9	0.04	0.030	1.5	120	160	0.5	5200	1.3	690	0.5	1.8	300.0	3.8	5900.0	1400
22	9	0.04	0.040	1.5	83	170	0.5	6400	2.5	960	0.5	2.1	220.0	2.7	6700.0	1000
22	9	0.04	0.020	1.1	97	110	0.5	4200	1.6	660	0.5	1.6	230.0	3.2	4600.0	960
22	10	0.04	0.050	2.1	5	420	0.5	8200	3.3	960	0.5	3.2	190.0	5.3	9100.0	1400
22	10	0.10	0.050	1.9	5	630	0.5	7700	3.1	1100	0.5	2.4	300.0	8.1	8800.0	1200
22	10	0.18	0.050	1.5	5	660	0.5	6600	2.4	940	0.5	1.7	210.0	8.1	6500.0	1200
22	11	0.04	0.010	0.4	110	40	0.5	490	0.6	88	0.5	0.9	200.0	2.1	1700.0	20
22	11	0.04	0.030	0.3	100	20	0.5	250	0.6	50	0.5	0.6	180.0	2.1	1600.0	20
22	11	0.04	0.010	0.5	100	50	0.5	780	0.7	120	0.5	0.7	230.0	2.8	2000.0	80
22	12	0.04	0.010	0.4	96	30	0.5	800	0.9	94	0.5	0.6	260.0	2.3	2200.0	30
22	12	0.04	0.010	0.4	96	40	0.5	860	0.8	67	0.5	0.6	260.0	2.1	2300.0	70
22	12	0.04	0.010	0.3	100	20	0.5	830	0.7	86	0.5	0.6	260.0	3.1	2000.0	98
22	12	0.06	0.010	0.4	6	40	0.5	630	0.7	160	0.5	0.8	210.0	2.4	2000.0	90
22	12	0.15	0.010	0.3	5	50	0.5	490	0.7	190	0.5	1.1	270.0	2.8	2200.0	50
22	12	0.15	0.010	0.3	6	60	0.5	420	0.8	260	0.5	1.1	290.0	3.8	2400.0	40
22	13	0.04	0.020	0.3	5	40	0.5	470	0.7	61	0.5	0.5	280.0	2.5	2200.0	20
22	13	0.12	0.020	0.6	5	40	0.5	560	0.7	77	0.5	0.7	200.0	2.2	2200.0	30
22	13	0.04	0.020	0.5	5	40	0.5	770	0.8	100	0.5	0.9	280.0	2.6	2700.0	80
22	13	0.07	0.010	0.3	7	90	0.5	790	0.6	610	0.5	0.7	270.0	3.3	2300.0	90
22	13	0.06	0.020	0.4	20	120	0.5	1200	0.8	560	0.5	0.5	300.0	3.8	2700.0	150
22	13	0.10	0.020	0.3	8	70	0.5	550	0.7	360	0.5	0.8	280.0	4.3	2700.0	40
22	14	0.04	0.020	0.4	26	30	0.5	350	0.5	84	0.5	0.5	160.0	2.2	1500.0	20
22	14	0.04	0.010	0.4	5	30	0.5	340	0.6	73	0.5	0.5	190.0	2.1	1700.0	30
22	14	0.04	0.010	0.3	5	50	0.5	510	0.9	160	0.5	0.9	350.0	4.2	2600.0	50
22	14	0.18	0.010	0.3	110	80	0.5	620	0.8	210	0.5	0.8	290.0	2.8	2300.0	40
22	14	0.04	0.005	0.3	110	50	0.5	780	0.6	230	0.5	0.5	220.0	2.6	2000.0	170

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	PB210	RA226	URAN	BORON	PHOSPH	SILV	ALUMIN	BER	CALCIUM	CADM	COB	CHROM	COPP	IRON	POTASS
22	14	0.16	0.010	0.4	120	80	0.5	770	0.8	510	0.5	0.5	270.0	3.9	2800.0	97
22	15	0.04	0.010	0.4	5	50	0.5	590	0.5	130	0.5	0.6	100.0	2.1	1200.0	20
22	15	0.04	0.020	0.4	10	30	0.5	490	0.5	96	0.5	0.5	150.0	2.0	1500.0	40
22	15	0.06	0.020	0.6	5	70	0.5	690	0.7	200	0.5	0.5	230.0	3.1	2300.0	90
22	15	0.15	0.020	0.4	8	100	1.7	750	0.7	390	0.5	0.5	230.0	4.8	2300.0	20
22	15	0.07	0.010	0.4	100	50	0.5	550	0.5	190	0.5	0.5	200.0	3.8	1600.0	20
22	15	0.13	0.010	0.3	100	90	0.5	820	0.8	410	0.5	0.8	320.0	4.2	2900.0	60
22	16	0.04	0.010	0.5	6	30	0.5	690	0.6	120	0.5	0.6	200.0	28.0	1800.0	110
22	16	0.06	0.010	0.5	5	60	0.5	1300	0.8	210	0.5	0.7	220.0	2.8	2600.0	130
22	16	0.07	0.010	0.5	6	50	0.5	570	0.6	210	0.5	0.5	190.0	2.2	1800.0	50
22	16	0.04	0.010	0.5	22	30	0.5	620	0.5	63	0.5	0.5	100.0	1.4	1100.0	40
22	16	0.04	0.010	0.4	6	40	0.5	400	0.5	61	0.5	0.5	160.0	1.7	1400.0	20
22	16	0.04	0.010	0.4	6	50	0.5	580	0.6	91	0.5	0.6	220.0	1.9	1800.0	60
22	17	0.06	0.070	5.0	5	320	0.5	11000	3.0	1200	0.6	4.0	80.0	7.0	13000.0	420
22	17	0.04	0.090	12.0	5	380	0.5	20000	4.0	2100	0.5	8.0	130.0	6.0	17000.0	740
22	17	0.08	0.170	10.0	5	120	0.5	10000	2.0	1300	0.5	3.0	84.0	2.0	9400.0	590
22	18	3.00	6.000	967.0	5	300	0.5	15000	4.0	1200	0.5	66.0	100.0	90.0	15000.0	410
22	18	0.09	0.200	2.3	5	120	0.5	12000	3.0	930	0.5	6.0	53.0	17.0	1000.0	340
22	18	0.07	0.120	4.8	5	560	0.5	16000	4.0	900	0.8	18.0	61.0	45.0	12000.0	740
22	19	0.04	0.020	0.9	9	55	0.5	2900	1.0	1100	0.7	2.0	89.0	3.0	4100.0	470
22	19	0.04	0.020	1.3	5	140	0.5	4100	2.0	1000	0.7	2.0	160.0	3.0	8600.0	450
22	19	0.04	0.020	0.9	5	63	0.5	2200	0.6	660	0.5	1.0	96.0	3.0	2900.0	480
22	20	0.04	0.020	0.9	5	260	0.5	8300	2.0	1500	0.8	3.0	82.0	3.0	9900.0	680
22	20	0.04	0.020	0.9	5	230	0.5	5900	1.0	1200	0.5	3.0	100.0	4.0	7000.0	590
22	20	0.04	0.020	0.9	5	120	0.5	6100	1.0	740	5.0	2.0	120.0	4.0	6600.0	300
22	21	0.04	0.050	5.2	5	300	0.5	6900	2.0	2600	0.5	4.0	83.0	6.0	6200.0	1300
22	21	0.04	0.040	1.9	5	160	0.5	6700	1.0	1300	0.6	2.0	68.0	4.0	4200.0	1100
22	21	0.04	0.030	3.6	5	220	0.5	7300	2.0	2100	0.5	3.0	130.0	4.0	10000.0	940
22	22	0.04	0.030	0.9	5	340	0.5	3700	1.0	1200	0.5	2.0	88.0	3.0	6000.0	340
22	22	0.04	0.030	1.2	5	190	0.5	3400	0.9	670	0.6	2.0	100.0	2.0	5200.0	450
22	22	0.04	0.020	1.1	5	330	0.5	5800	2.0	1800	0.6	5.0	120.0	3.0	10000.0	1200

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	MAGNES	MANGAN	MOLY	SODIUM	NICKL	LEAD	TITAN	VANA	ZINC	BARIUM	TRNSF	FIRE	NEED	LOI	H2O
1	1	39000	77000.0	.	910	34.0	1	32.0	27	790.0	140.0	2.990	0	.	.	.
1	1	36000	110000.0	.	860	32.0	1	73.0	37	940.0	86.0	2.991	0	.	.	.
1	1	46000	130000.0	.	650	30.0	1	26.0	37	840.0	130.0	3.403	0	.	.	.
1	2	57000	21000.0	.	840	54.0	1	10.0	26	510.0	99.0	2.969	0	.	.	.
1	2	64000	21000.0	.	550	55.0	1	66.0	38	530.0	28.0	3.167	0	.	.	.
1	2	70000	28000.0	.	730	55.0	1	25.0	25	660.0	27.0	2.497	0	.	.	.
1	5	53500	28500.0	18	1100	31.0	2	120.0	28	1070.0	285.0	2.785	0	.	.	.
1	5	65000	19000.0	14	670	38.0	2	110.0	25	760.0	460.0	2.768	0	.	.	.
1	5	62000	41000.0	15	550	49.0	2	56.0	25	1300.0	260.0	2.327	0	.	.	.
1	6	68000	20000.0	13	1500	95.0	6	130.0	25	710.0	1200.0	2.606	0	.	.	.
1	6	63000	20000.0	15	630	83.0	2	89.0	27	460.0	830.0	2.160	0	.	.	.
1	6	73000	13000.0	9	540	100.0	2	69.0	21	830.0	340.0	2.787	0	.	.	.
1	8	56000	70000.0	15	700	34.0	2	63.0	24	780.0	390.0	2.848	0	.	.	.
1	8	50000	42000.0	18	680	40.0	2	84.0	35	870.0	320.0	3.030	0	.	.	.
1	8	49000	69000.0	15	610	42.0	2	68.0	29	900.0	230.0	2.977	0	.	.	.
1	9	72000	54000.0	21	470	62.0	2	54.0	36	1000.0	210.0	3.171	0	.	.	.
1	9	56000	59000.0	17	520	69.0	2	62.0	31	960.0	240.0	2.865	0	.	.	.
1	9	45000	45400.0	16	720	44.0	2	70.0	30	900.0	290.0	2.958	0	.	.	.
1	10	63000	24000.0	24	770	86.0	2	140.0	42	630.0	790.0	3.739	0	.	.	.
1	10	51000	38000.0	10	620	57.0	2	60.0	21	660.0	320.0	2.580	0	.	.	.
1	10	76000	47000.0	17	790	74.0	2	70.0	25	1200.0	1300.0	3.425	0	.	.	.
1	11	51000	100000.0	25	950	47.0	2	79.0	48	700.0	390.0	3.359	0	.	.	.
1	11	32000	120000.0	25	800	21.0	2	67.0	43	930.0	300.0	3.298	0	.	.	.
1	11	39000	110000.0	18	520	24.0	2	63.0	36	1000.0	1200.0	3.166	0	.	.	.
1	12	53000	54000.0	19	1600	29.0	2	200.0	41	570.0	840.0	3.180	0	.	.	.
1	12	39000	120000.0	30	540	37.0	2	93.0	55	870.0	400.0	3.090	0	.	.	.
1	12	41000	97000.0	30	960	60.0	2	130.0	61	1000.0	280.0	2.696	0	.	.	.
1	12	46000	140000.0	27	700	48.0	2	97.0	52	1900.0	300.0	2.771	1	.	.	.
1	12	48000	78000.0	18	1200	43.0	2	76.0	33	1500.0	300.0	3.005	1	.	.	.
1	12	39000	100000.0	18	610	37.0	2	45.0	33	800.0	260.0	2.966	1	.	.	.
1	13	45000	97000.0	23	740	31.0	2	75.0	45	780.0	550.0	3.367	0	.	.	.
1	13	48000	100000.0	23	720	22.0	2	74.0	50	1100.0	230.0	3.358	0	.	.	.
1	13	49000	82000.0	15	600	23.0	2	62.0	31	870.0	1200.0	3.187	0	.	.	.
1	13	38000	64000.0	14	330	22.0	2	45.0	27	960.0	1100.0	3.551	1	.	.	.
1	13	37000	65000.0	13	680	25.0	2	67.0	26	1400.0	400.0	3.117	1	.	.	.
1	13	55000	55000.0	12	550	31.0	2	38.0	22	970.0	240.0	3.333	1	.	.	.
1	14	43000	110000.0	28	590	27.0	2	76.0	54	920.0	420.0	3.712	0	.	.	.
1	14	33000	89000.0	24	910	30.0	2	120.0	53	700.0	430.0	3.283	0	.	.	.
1	14	53000	81500.0	23	750	34.0	2	88.0	46	1200.0	430.0	3.187	0	.	.	.
1	14	47000	63000.0	16	670	21.0	2	93.0	31	1100.0	710.0	2.812	1	.	.	.
1	14	38300	40800.0	18	590	30.0	3	81.0	35	1300.0	370.0	2.855	1	.	.	.
1	14	50000	30000.0	12	560	17.0	2	58.0	24	1100.0	1000.0	3.237	1	.	.	.
1	15	45400	102000.0	16	650	33.0	2	69.0	36	910.0	230.0	2.929	0	.	.	.
1	15	61000	120000.0	19	670	18.0	2	80.0	41	780.0	1300.0	3.373	0	.	.	.
1	15	28000	113000.0	22	510	25.0	2	50.0	39	750.0	250.0	3.456	0	.	.	.
1	15	39000	98100.0	18	390	16.0	2	38.0	32	1200.0	470.0	2.688	1	.	.	.
1	15	35800	102000.0	18	770	24.0	2	44.0	35	1100.0	290.0	2.920	1	.	.	.
1	15	29000	104500.0	20	860	28.0	2	51.0	35	1030.0	840.0	3.372	1	.	.	.
1	16	35700	130000.0	19	950	16.0	8	95.0	38	730.0	340.0	3.955	0	.	.	.
1	16	56200	88600.0	17	680	20.0	2	75.0	37	520.0	300.0	4.108	0	.	.	.
1	16	47200	95600.0	18	620	16.0	3	73.0	38	730.0	230.0	3.635	0	.	.	.
1	16	43600	61900.0	17	870	23.0	2	86.0	33	850.0	320.0	3.744	1	.	.	.
1	16	35100	106000.0	21	760	27.0	2	99.0	43	740.0	380.0	3.429	1	.	.	.
1	16	38400	102000.0	17	710	15.0	2	90.0	34	740.0	450.0	3.809	1	.	.	.
2	1	33600	24600.0	.	670	72.0	2	80.0	32	2200.0	350.0	2.581	0	0	.	.

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	MAGNES	MANGAN	MOLY	SODIUM	NICKL	LEAD	TITAN	VANA	ZINC	BARIUM	TRNSF	FIRE	NEED	LOI	H2O
2	1	31000	30400.0	.	550	70.0	2	36.0	34	3600.0	410.0	2.327	0	0	.	.
2	1	31400	23200.0	.	760	83.0	2	86.0	36	2300.0	550.0	2.106	0	0	.	.
2	11	34000	34000.0	27	340	28.0	4	50.0	29	3500.0	290.0	2.305	0	1	.	.
2	11	36000	25000.0	29	450	19.0	12	48.0	31	4000.0	240.0	2.605	0	1	.	.
2	11	32000	28000.0	29	420	14.0	8	62.0	33	3400.0	330.0	2.536	0	1	.	.
2	12	38000	47000.0	24	450	35.0	4	54.0	47	4000.0	270.0	2.502	0	1	.	.
2	12	43000	30000.0	28	810	31.0	2	57.0	31	2800.0	430.0	2.389	0	1	.	.
2	12	35000	23000.0	23	360	19.0	2	32.0	22	1600.0	350.0	2.477	0	1	.	.
2	12	40000	23000.0	28	400	42.0	2	32.0	22	2600.0	370.0	2.117	1	1	.	.
2	12	48000	25000.0	31	470	36.0	12	46.0	24	3200.0	180.0	2.025	1	1	.	.
2	12	35000	26000.0	34	1100	46.0	5	41.0	29	3800.0	190.0	1.953	1	1	.	.
2	13	35000	28000.0	27	400	35.0	4	36.0	30	2950.0	310.0	2.171	0	1	.	.
2	13	43000	22000.0	20	720	24.0	2	43.0	25	2100.0	340.0	2.477	0	1	.	.
2	13	34000	21000.0	21	590	17.0	4	32.0	22	2600.0	160.0	2.357	0	1	.	.
2	13	48000	9800.0	22	240	11.0	4	19.0	20	2600.0	130.0	2.259	1	1	.	.
2	13	39000	15000.0	31	950	12.0	13	26.0	24	3400.0	390.0	2.313	1	1	.	.
2	13	48000	11000.0	33	950	15.0	15	43.0	26	4400.0	250.0	2.648	1	1	.	.
2	14	40000	28000.0	20	1400	23.0	2	44.0	26	2400.0	130.0	2.741	0	1	.	.
2	14	40000	35000.0	26	390	25.0	2	70.0	40	3700.0	130.0	2.269	0	1	.	.
2	14	45000	43000.0	21	980	24.0	2	69.0	33	4200.0	170.0	2.072	0	1	.	.
2	14	44000	24000.0	32	450	13.0	16	37.0	40	5700.0	190.0	2.008	1	1	.	.
2	14	65000	18000.0	37	360	23.0	27	31.0	33	4900.0	63.0	1.715	1	1	.	.
2	14	51000	11000.0	27	380	25.0	4	24.0	20	3000.0	97.0	1.558	1	1	.	.
2	15	35000	57000.0	32	710	59.0	2	77.0	42	4800.0	450.0	2.282	0	1	.	.
2	15	37000	39000.0	31	510	44.0	4	65.0	40	3400.0	340.0	2.357	0	1	.	.
2	15	32000	60000.0	32	600	61.0	9	54.0	35	4400.0	190.0	2.144	0	1	.	.
2	15	38000	27000.0	36	570	43.0	2	21.0	20	3000.0	330.0	1.657	1	1	.	.
2	15	38000	34000.0	37	350	38.0	4	12.0	24	2600.0	360.0	2.073	1	1	.	.
2	15	41000	31000.0	39	260	41.0	8	23.0	22	3500.0	410.0	2.072	1	1	.	.
2	16	26000	31000.0	34	450	25.0	11	64.0	36	3000.0	380.0	3.050	0	1	.	.
2	16	31000	35000.0	23	500	22.0	4	52.0	28	2100.0	360.0	2.588	0	1	.	.
2	16	37000	30000.0	27	410	15.0	8	64.0	30	2300.0	370.0	2.901	0	1	.	.
2	16	35000	23000.0	24	480	23.0	7	66.0	28	1800.0	690.0	2.512	1	1	.	.
2	16	33000	27000.0	23	720	17.0	4	51.0	25	1600.0	540.0	2.542	1	1	.	.
2	16	36000	27000.0	29	1000	72.0	2	92.0	33	2300.0	240.0	2.070	1	1	.	.
2	17	40000	24000.0	25	400	37.0	21	56.0	20	2000.0	500.0	2.200	0	1	.	.
2	17	43000	20000.0	28	450	46.0	29	12.0	20	2200.0	490.0	1.900	0	1	.	.
2	17	44000	19000.0	21	420	21.0	22	52.0	19	2200.0	260.0	2.100	0	1	.	.
2	18	46000	28000.0	30	240	240.0	23	51.0	30	2100.0	330.0	2.100	0	1	.	.
2	18	48000	20000.0	28	340	260.0	29	67.0	32	2200.0	400.0	1.800	0	1	.	.
2	18	48000	34000.0	27	250	250.0	19	59.0	34	1900.0	210.0	2.200	0	1	.	.
2	19	43000	9600.0	16	210	23.0	15	30.0	18	1350.0	320.0	2.200	0	1	.	.
2	19	32000	6500.0	15	120	26.0	10	29.0	19	1400.0	240.0	2.200	0	1	.	.
2	19	33000	7800.0	22	270	25.0	13	46.0	23	1300.0	440.0	2.000	0	1	.	.
2	20	45500	16000.0	22	200	82.0	20	34.0	20	1700.0	430.0	2.000	0	1	.	.
2	20	42000	17000.0	20	180	60.0	17	44.0	22	2100.0	650.0	2.000	0	1	.	.
2	20	56000	14000.0	21	310	120.0	20	44.0	23	2800.0	280.0	1.900	0	1	.	.
3	1	41600	11900.0	.	560	49.0	6	46.0	18	390.0	1300.0	2.969	0	.	.	.
3	1	45700	20800.0	.	520	50.0	2	50.0	28	680.0	400.0	2.733	0	.	.	.
3	1	46400	23500.0	.	740	18.0	2	60.0	30	680.0	470.0	3.193	0	.	.	.
3	2	32300	11100.0	.	600	35.0	4	32.0	16	560.0	130.0	2.789	0	.	.	.
3	2	33000	7900.0	.	480	62.0	2	25.0	22	470.0	200.0	2.819	0	.	.	.
3	2	38000	10600.0	.	440	29.0	4	24.0	14	570.0	270.0	2.769	0	.	.	.
3	6	45000	22400.0	13	530	22.0	2	45.0	26	970.0	640.0	2.760	0	.	.	.
3	6	46300	19500.0	12	690	22.0	2	8.0	22	1000.0	140.0	2.534	0	.	.	.

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	MAGNES	MANGAN	MOLY	SODIUM	NICKL	LEAD	TITAN	VANA	ZINC	BARIUM	TRNSF	FIRE	NEED	LOI	H2O
3	6	50000	28800.0	13	990	24.0	9	30.0	24	1100.0	250.0	2.661	0	.	.	.
3	7	41600	15600.0	9	700	29.0	2	41.0	18	690.0	310.0	2.613	0	.	.	.
3	7	33000	12000.0	15	630	37.0	7	79.0	26	630.0	350.0	2.234	0	.	.	.
3	7	38100	19700.0	14	780	53.0	2	100.0	27	910.0	930.0	2.745	0	.	.	.
3	8	41700	32000.0	15	800	24.0	12	60.0	29	920.0	880.0	2.835	0	.	.	.
3	8	37500	29700.0	15	820	28.0	5	120.0	30	940.0	910.0	2.689	0	.	.	.
3	8	32000	30000.0	15	760	38.0	2	91.0	27	860.0	810.0	2.677	0	.	.	.
3	9	40600	19900.0	11	1700	39.0	2	78.0	23	940.0	220.0	2.267	0	.	.	.
3	9	36000	23000.0	15	1000	42.0	2	77.0	28	880.0	1200.0	2.523	0	.	.	.
3	9	39900	19700.0	12	630	38.0	7	70.0	24	870.0	730.0	2.549	0	.	.	.
3	10	40100	36100.0	15	800	17.0	2	91.0	27	790.0	1000.0	2.637	0	.	.	.
3	10	47200	33400.0	17	690	29.0	2	85.0	31	820.0	650.0	2.599	0	.	.	.
3	10	45000	36700.0	14	860	20.0	2	88.0	26	770.0	430.0	2.516	0	.	.	.
3	17	48000	21000.0	11	1000	36.0	2	90.0	26	660.0	620.0	2.900	0	.	.	.
3	18	58000	25000.0	8	470	78.0	7	46.0	26	810.0	530.0	2.400	0	.	.	.
3	18	43000	37000.0	8	400	58.0	6	54.0	25	850.0	690.0	2.700	0	.	.	.
3	18	48000	42000.0	12	390	71.0	5	13.0	21	740.0	460.0	2.900	0	.	.	.
3	19	42500	24000.0	15	420	38.0	2	46.0	23	710.0	525.0	2.500	0	.	.	.
3	19	46000	17000.0	11	560	55.0	2	37.0	24	780.0	500.0	2.600	0	.	.	.
3	19	36500	22500.0	16	470	16.0	2	36.0	24	820.0	425.0	2.400	0	.	.	.
3	20	43000	15000.0	15	1500	69.0	2	33.0	26	820.0	710.0	2.400	0	.	.	.
3	20	44000	30000.0	9	390	36.0	8	26.0	22	880.0	220.0	2.600	0	.	.	.
3	20	62000	13000.0	7	5900	130.0	2	35.0	21	760.0	1000.0	2.300	0	.	.	.
3	21	48000	40000.0	13	430	45.0	6	25.0	30	990.0	560.0	2.200	0	.	.	.
3	21	48000	37000.0	7	200	20.0	2	8.0	22	780.0	1100.0	2.300	0	.	.	.
3	21	52000	29000.0	6	340	27.0	2	8.0	20	760.0	430.0	2.300	0	.	.	.
3	22	43000	24000.0	10	490	68.0	2	42.0	25	860.0	660.0	2.200	0	.	.	.
3	22	38000	23000.0	7	350	20.0	2	30.0	20	830.0	84.0	2.300	0	.	.	.
3	22	38000	25000.0	6	300	20.0	2	23.0	20	700.0	940.0	2.500	0	.	.	.
4	2	63000	1800.0	.	510	89.0	1	28.0	19	310.0	34.0	3.255	0	.	.	.
4	2	53000	200.0	.	360	81.0	2	7.0	14	280.0	280.0	3.069	0	.	.	.
4	2	53000	700.0	.	340	110.0	1	37.0	21	380.0	45.0	3.121	0	.	.	.
4	5	.	.	.	.	.	.	.	.	.	.	1.988	0	.	.	.
4	5	.	.	.	.	.	.	.	.	.	.	1.608	0	.	.	.
4	5	55200	1900.0	47	310	110.0	2	82.0	49	2200.0	420.0	1.546	0	.	.	.
4	7	.	.	.	.	.	.	.	.	.	.	1.857	0	.	.	.
4	7	.	.	.	.	.	.	.	.	.	.	2.778	0	.	.	.
4	7	.	.	.	.	.	.	.	.	.	.	1.846	0	.	.	.
4	10	54600	4200.0	24	370	99.0	17	74.0	38	780.0	880.0	2.523	0	.	.	.
4	10	.	.	.	.	.	.	.	.	.	.	1.991	0	.	.	.
4	10	.	.	.	.	.	.	.	.	.	.	1.677	0	.	.	.
4	11	42300	7300.0	14	580	49.0	3	31.0	20	290.0	840.0	2.899	0	.	.	.
4	11	30400	6200.0	10	300	15.0	2	41.0	18	220.0	800.0	3.522	0	.	.	.
4	11	35800	7100.0	12	500	17.0	11	48.0	20	240.0	550.0	2.956	0	.	.	.
4	12	23500	10100.0	13	200	39.0	7	41.0	29	640.0	750.0	3.183	0	.	.	.
4	12	28400	2900.0	18	170	40.0	7	48.0	35	710.0	500.0	2.335	0	.	.	.
4	12	27000	6200.0	16	340	34.0	2	60.0	23	840.0	680.0	2.335	0	.	.	.
4	16	46900	2800.0	14	280	45.0	2	33.0	19	590.0	590.0	2.528	0	.	.	.
4	16	40100	6200.0	15	600	31.0	6	110.0	30	860.0	470.0	2.043	0	.	.	.
4	16	51000	4200.0	13	380	43.0	2	70.0	24	720.0	530.0	2.310	0	.	.	.
4	17	48000	2700.0	34	1300	41.0	5	76.0	32	370.0	650.0	1.900	0	.	.	.
4	17	36000	16000.0	56	780	97.0	5	30.0	27	1600.0	2400.0	2.800	0	.	.	.
4	17	17000	3600.0	39	260	14.0	11	8.0	8	260.0	1165.0	4.400	0	.	.	.
4	18	36000	12000.0	2	590	210.0	110	30.0	16	1700.0	1500.0	2.300	0	.	.	.
4	18	44000	7500.0	51	80	280.0	5	35.0	32	2100.0	1400.0	2.000	0	.	.	.

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	MAGNES	MANGAN	MOLY	SODIUM	NICKL	LEAD	TITAN	VANA	ZINC	BARIUM	TRNSF	FIRE	NEED	LOI	H2O
4	18	47000	12000.0	5	780	350.0	20	47.0	12	3100.0	1100.0	1.900	0	.	.	.
4	19	26000	2400.0	74	320	20.0	160	14.0	20	930.0	810.0	3.000	0	.	.	.
4	19	56000	3400.0	56	460	150.0	5	7.0	30	880.0	1300.0	2.200	0	.	.	.
4	20	38000	2700.0	200	390	40.0	5	10.0	26	1000.0	2200.0	2.400	0	.	.	.
4	20	40000	3700.0	18	500	90.0	30	9.0	22	1400.0	3000.0	2.300	0	.	.	.
4	20	55000	2800.0	14	800	200.0	5	15.0	29	4300.0	1000.0	1.900	0	.	.	.
5	1	35900	28000.0	.	900	170.0	5	22.0	27	1800.0	760.0	1.900	0	.	.	.
5	1	41000	46500.0	.	580	28.0	2	3.0	20	810.0	120.0	2.973	0	.	.	.
5	1	38500	38400.0	.	700	11.0	2	1.0	25	810.0	160.0	2.508	0	.	.	.
5	2	36000	30000.0	.	490	11.0	2	1.0	23	930.0	350.0	2.578	0	.	.	.
5	2	39000	31000.0	.	540	14.0	1	21.0	17	470.0	690.0	2.668	0	.	.	.
5	2	40000	38000.0	.	360	12.0	1	32.0	22	420.0	34.0	3.237	0	.	.	.
5	5	57000	31000.0	16	1100	18.0	1	25.0	24	560.0	48.0	3.484	0	.	.	.
5	5	38000	36000.0	18	620	15.0	2	47.0	26	880.0	640.0	2.738	0	.	.	.
5	5	57000	33000.0	12	280	16.0	2	37.0	28	710.0	760.0	2.992	0	.	.	.
5	6	48000	41000.0	12	310	24.0	2	19.0	21	980.0	190.0	2.703	0	.	.	.
5	6	48000	28000.0	18	470	36.0	2	27.0	17	1100.0	330.0	2.837	0	.	.	.
5	6	52000	29000.0	17	590	11.0	2	73.0	27	780.0	900.0	2.765	0	.	.	.
5	7	47000	47000.0	22	340	21.0	9	40.0	28	860.0	770.0	3.118	0	.	.	.
5	7	53000	18000.0	11	500	22.0	2	36.0	33	750.0	460.0	2.653	0	.	.	.
5	7	46000	49000.0	14	600	22.0	2	1.0	17	570.0	30.0	2.892	0	.	.	.
5	8	47000	63000.0	20	680	62.0	2	37.0	22	860.0	280.0	2.520	0	.	.	.
5	8	44000	67000.0	16	460	14.0	2	83.0	32	890.0	1000.0	2.766	0	.	.	.
5	8	33000	66000.0	27	700	19.0	2	47.0	22	890.0	210.0	3.073	0	.	.	.
5	9	33000	59000.0	19	280	18.0	2	37.0	37	680.0	640.0	3.134	0	.	.	.
5	9	38000	46000.0	28	250	8.0	2	30.0	28	660.0	560.0	2.981	0	.	.	.
5	9	38000	55000.0	16	300	30.0	2	60.0	35	740.0	790.0	3.183	0	.	.	.
5	10	50000	55000.0	15	680	20.0	2	42.0	20	910.0	120.0	2.830	0	.	.	.
5	10	50000	68000.0	23	670	11.0	2	43.0	21	690.0	130.0	2.912	0	.	.	.
5	10	44000	72000.0	17	540	8.0	2	61.0	36	820.0	380.0	2.520	0	.	.	.
5	11	37000	81000.0	16	700	15.0	2	77.0	23	780.0	190.0	2.511	0	.	.	.
5	11	38000	63000.0	14	420	9.0	2	39.0	25	570.0	240.0	2.978	0	.	.	.
5	11	37000	63000.0	14	340	5.0	2	51.0	26	700.0	940.0	3.601	0	.	.	.
5	12	40000	49000.0	13	520	9.0	2	47.0	24	600.0	340.0	3.390	0	.	.	.
5	12	46000	30000.0	12	400	15.0	2	62.0	28	540.0	200.0	2.992	0	.	.	.
5	12	37000	41000.0	13	680	32.0	2	82.0	23	660.0	210.0	2.913	0	.	.	.
5	13	59000	67000.0	16	450	15.0	2	<0.2	19	670.0	36.0	3.236	0	.	.	.
5	13	34000	78000.0	20	940	40.0	2	53.0	30	1200.0	170.0	2.762	0	.	.	.
5	13	44000	60000.0	23	290	7.0	2	48.0	32	800.0	500.0	3.303	0	.	.	.
5	14	65000	71000.0	18	430	9.0	2	46.0	33	680.0	450.0	3.509	0	.	.	.
5	14	52000	34000.0	13	710	12.0	2	76.0	32	1000.0	200.0	2.473	0	.	.	.
5	14	51000	46000.0	12	400	12.0	2	40.0	20	730.0	270.0	2.921	0	.	.	.
5	15	50000	54000.0	20	320	19.0	2	32.0	20	650.0	180.0	3.115	0	.	.	.
5	15	48000	67000.0	21	570	14.0	2	47.0	37	940.0	400.0	2.889	0	.	.	.
5	15	42000	65000.0	16	480	7.0	2	86.0	39	680.0	630.0	2.771	0	.	.	.
5	16	40000	68000.0	17	440	18.0	2	44.0	32	810.0	160.0	3.146	0	.	.	.
5	17	37000	56000.0	14	540	10.0	2	1.0	27	870.0	32.0	3.940	0	.	.	.
5	17	44000	61000.0	28	490	22.0	2	36.0	26	520.0	150.0	2.700	0	.	.	.
5	17	50000	39000.0	16	860	24.0	19	67.0	39	750.0	560.0	2.500	0	.	.	.
5	18	42000	57000.0	16	1100	20.0	2	71.0	28	440.0	410.0	2.800	0	.	.	.
5	18	54000	63000.0	11	560	28.0	2	38.0	24	600.0	180.0	2.600	0	.	.	.
5	18	52000	43000.0	13	280	28.0	2	25.0	27	620.0	130.0	2.500	0	.	.	.
5	19	50000	40000.0	20	640	66.0	2	37.0	23	530.0	100.0	2.200	0	.	.	.
5	19	34000	36000.0	11	330	5.0	2	25.0	20	590.0	370.0	2.700	0	.	.	.
					230	10.0	8	17.0	17	490.0	400.0	2.700	0	.	.	.

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	MAGNES	MANGAN	MOLY	SODIUM	NICKL	LEAD	TITAN	VANA	ZINC	BARIUM	TRNSF	FIRE	NEED	LOI	H2O
5	19	48000	48000.0	42	360	18.0	3	34.0	32	920.0	540.0	2.900	0	.	.	.
5	20	40000	35000.0	13	280	14.0	2	17.0	19	700.0	390.0	2.900	0	.	.	.
5	20	47000	50000.0	14	500	23.0	2	44.0	24	920.0	260.0	2.500	0	.	.	.
5	20	45000	28000.0	11	220	38.0	2	14.0	20	690.0	150.0	3.000	0	.	.	.
5	21	59000	53000.0	16	400	8.0	2	19.0	25	660.0	420.0	2.600	0	.	.	.
5	21	49000	40000.0	12	200	12.0	2	8.0	25	710.0	610.0	2.600	0	.	.	.
5	21	40000	45000.0	13	230	7.0	2	9.0	23	790.0	150.0	2.600	0	.	.	.
5	22	44500	42500.0	16	580	22.0	2	42.0	28	680.0	330.0	2.500	0	.	.	.
5	22	38500	46000.0	21	350	13.0	16	27.0	32	1300.0	515.0	2.600	0	.	.	.
5	22	40000	38000.0	13	490	13.0	2	0.5	25	740.0	97.0	2.300	0	.	.	.
6	1	33500	36400.0	.	300	13.0	3	1.0	22	2100.0	790.0	2.470	0	0	.	.
6	1	35300	27800.0	.	390	24.0	2	1.0	32	2100.0	540.0	2.589	0	0	.	.
6	1	36700	43900.0	.	480	23.0	4	18.0	22	1800.0	1500.0	2.737	0	0	.	.
6	2	40500	12000.0	.	430	34.0	2	31.0	31	1600.0	320.0	2.183	0	0	.	.
6	2	40400	11700.0	.	460	24.0	4	24.0	18	1400.0	1000.0	2.383	0	0	.	.
6	2	46500	10200.0	.	500	19.0	12	27.0	20	1200.0	620.0	2.214	0	0	.	.
6	5	54000	13000.0	11	1500	19.0	6	16.0	20	1300.0	660.0	2.163	0	1	.	.
6	5	38700	17600.0	15	640	12.0	2	15.0	24	1700.0	560.0	2.409	0	1	.	.
6	5	53700	18900.0	32	590	46.0	4	21.0	49	2100.0	390.0	2.027	0	1	.	.
6	6	43300	16600.0	28	350	84.0	2	12.0	42	1700.0	670.0	2.222	0	1	.	.
6	6	44000	14000.0	15	710	28.0	2	13.0	26	2100.0	1200.0	2.297	0	1	.	.
6	6	44900	18800.0	23	610	99.0	10	22.0	37	1700.0	1100.0	2.354	0	1	.	.
6	7	44200	21600.0	15	840	42.0	2	9.0	25	1600.0	760.0	2.287	0	1	.	.
6	7	42000	18100.0	18	580	36.0	2	22.0	28	1400.0	500.0	2.153	0	1	.	.
6	7	25000	9600.0	6	150	17.0	2	7.0	8	810.0	470.0	2.221	0	1	.	.
6	8	32000	33000.0	8	220	17.0	4	8.0	14	1300.0	970.0	2.477	0	1	.	.
6	8	34400	20100.0	21	730	41.0	2	20.0	32	1900.0	690.0	2.252	0	1	.	.
6	8	33000	23000.0	16	780	15.0	2	21.0	24	1800.0	880.0	2.491	0	1	.	.
6	9	33000	12000.0	10	320	21.0	2	10.0	15	1400.0	860.0	2.677	0	1	.	.
6	9	31000	15000.0	12	970	27.0	2	12.0	19	1800.0	820.0	2.446	0	1	.	.
6	9	36500	15000.0	22	760	49.0	2	11.0	34	1500.0	260.0	2.066	0	1	.	.
6	10	47200	29300.0	21	620	24.0	2	15.0	35	1500.0	470.0	2.125	0	1	.	.
6	10	40600	18600.0	14	220	30.0	7	29.0	23	1300.0	570.0	2.331	0	1	.	.
6	10	41000	27000.0	11	200	17.0	2	10.0	18	1300.0	300.0	2.070	0	1	.	.
6	11	46400	24000.0	13	560	9.0	2	12.0	22	1700.0	430.0	2.152	0	1	.	.
6	11	46000	27000.0	13	610	16.0	2	12.0	21	2000.0	570.0	2.346	0	1	.	.
6	11	35000	30000.0	12	1400	5.0	6	13.0	19	1700.0	470.0	2.606	0	1	.	.
6	13	28000	32000.0	12	620	8.0	2	13.0	18	1800.0	800.0	3.360	0	1	.	.
6	13	33300	32300.0	15	250	14.0	2	4.0	26	1700.0	670.0	3.135	0	1	.	.
6	13	32100	19200.0	18	330	12.0	2	18.0	33	1300.0	460.0	2.950	0	1	.	.
6	14	36400	39900.0	12	150	5.0	2	7.0	22	1400.0	300.0	2.853	0	1	.	.
6	14	34000	32000.0	14	1000	21.0	2	12.0	25	2000.0	320.0	3.153	0	1	.	.
6	14	38000	24000.0	10	490	10.0	2	11.0	17	1700.0	330.0	3.104	0	1	.	.
6	17	38000	13000.0	17	420	37.0	9	41.0	25	2000.0	750.0	1.900	0	0	.	.
6	17	36000	21000.0	12	370	50.0	10	40.0	19	1600.0	480.0	2.200	0	0	.	.
6	17	34000	28000.0	10	700	8.0	2	22.0	20	1700.0	1500.0	2.400	0	1	.	.
6	18	42000	16000.0	16	400	150.0	84	32.0	27	1700.0	480.0	2.200	0	0	.	.
6	18	37000	26000.0	18	300	170.0	10	32.0	29	2000.0	890.0	2.300	0	0	.	.
6	18	56000	32000.0	10	510	195.0	5	2.0	22	1200.0	300.0	1.900	0	1	.	.
6	19	28000	22000.0	9	440	8.0	2	12.0	16	1800.0	1700.0	2.600	0	1	.	.
6	19	44000	17000.0	16	830	19.0	3	11.0	28	2400.0	810.0	2.000	0	1	.	.
6	19	33000	28000.0	15	790	5.0	6	9.0	22	2000.0	1200.0	2.200	0	1	.	.
6	20	34000	25000.0	11	1100	13.0	2	7.0	22	1700.0	1700.0	2.200	0	1	.	.
6	20	30000	20000.0	8	550	47.0	2	0.5	15	2000.0	360.0	2.400	0	1	.	.
6	20	47000	14000.0	11	810	100.0	4	9.0	22	1600.0	1500.0	2.300	0	1	.	.

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	MAGNES	MANGAN	MOLY	SODIUM	NICKL	LEAD	TITAN	VANA	ZINC	BARIUM	TRNSF	FIRE	NEED	LOI	H2O
6	21	41000	20000.0	8	480	12.0	8	0.5	15	2100.0	210.0	1.900	0	0	.	.
6	21	37000	27000.0	12	720	17.0	36	14.0	23	2600.0	1100.0	2.000	0	0	.	.
6	21	35000	22000.0	10	170	15.0	14	10.0	18	2100.0	880.0	1.800	0	0	.	.
6	22	33500	23000.0	10	210	42.0	3	20.0	19	2300.0	960.0	2.200	0	1	.	.
6	22	28500	37000.0	11	820	11.0	11	10.0	20	2250.0	615.0	2.300	0	1	.	.
6	22	38000	48000.0	15	980	12.0	6	17.0	27	2800.0	500.0	1.900	0	1	.	.
7	5	26700	4400.0	39	3400	59.0	88	650.0	97	2000.0	410.0	1.015	0	.	.	.
7	5	26000	4400.0	42	3800	52.0	86	770.0	100	2000.0	400.0	0.968	0	.	.	.
7	5	27000	3700.0	30	4100	44.0	54	670.0	84	1500.0	310.0	1.170	0	.	.	.
7	6	20000	4700.0	18	3900	26.0	53	440.0	53	1000.0	500.0	1.110	0	.	.	.
7	6	23000	5300.0	20	3200	27.0	77	480.0	62	1200.0	450.0	1.023	0	.	.	.
7	6	26800	7500.0	41	3700	49.0	120	680.0	96	2500.0	530.0	1.037	0	.	.	.
7	7	22000	3400.0	22	3100	31.0	110	480.0	66	1000.0	370.0	1.014	0	.	.	.
7	7	22500	5000.0	43	2100	56.0	310	670.0	100	2100.0	420.0	0.992	0	.	.	.
7	7	22000	5100.0	27	2500	34.0	76	560.0	73	1000.0	460.0	1.150	0	.	.	.
7	8	22000	7900.0	25	3500	33.0	85	570.0	73	1300.0	640.0	1.129	0	.	.	.
7	8	19000	7200.0	24	2500	30.0	110	530.0	72	1000.0	530.0	1.208	0	.	.	.
7	8	19800	7000.0	31	2100	38.0	160	550.0	85	1500.0	440.0	1.167	0	.	.	.
7	10	20200	7600.0	40	3400	47.0	120	730.0	100	1700.0	430.0	1.222	0	.	.	.
7	10	20000	5600.0	29	4700	28.0	48	610.0	70	830.0	380.0	1.175	0	.	.	.
7	10	18000	5400.0	23	2300	26.0	79	500.0	67	860.0	360.0	1.149	0	.	.	.
7	21	37000	12000.0	16	3400	33.0	78	310.0	63	1700.0	740.0	0.600	0	.	.	.
7	21	36000	9000.0	19	3100	41.0	68	94.0	71	2000.0	420.0	0.700	0	.	.	.
7	21	35000	10000.0	16	3100	54.0	91	130.0	60	1800.0	560.0	0.700	0	.	.	.
7	22	24000	10000.0	27	5000	42.0	110	600.0	92	1700.0	950.0	0.800	0	.	.	.
7	22	33000	16000.0	21	4600	33.0	80	480.0	83	1900.0	760.0	0.800	0	.	.	.
7	22	28000	9300.0	2	3300	23.0	72	420.0	56	1500.0	540.0	0.900	0	.	.	.
8	1	23600	2100.0	.	3300	36.0	22	440.0	56	1000.0	380.0	1.030	0	.	.	.
8	1	20600	7000.0	.	3800	35.0	44	490.0	60	1400.0	420.0	1.301	0	.	.	.
8	1	27800	6500.0	.	3400	61.0	50	370.0	52	1300.0	340.0	1.086	0	.	.	.
8	2	22100	2600.0	.	3000	46.0	40	480.0	63	1100.0	260.0	1.072	0	.	.	.
8	2	22900	2400.0	.	3400	88.0	64	520.0	66	1200.0	470.0	0.980	0	.	.	.
8	2	23500	2900.0	.	3200	37.0	48	530.0	62	1100.0	460.0	1.019	0	.	.	.
8	5	23000	2700.0	24	4600	34.0	81	560.0	66	980.0	610.0	1.040	0	.	.	.
8	5	19500	2100.0	31	3700	43.0	110	690.0	86	1200.0	510.0	1.014	0	.	.	.
8	5	23200	2200.0	27	2400	36.0	140	570.0	73	1200.0	500.0	0.957	0	.	.	.
8	10	16000	4200.0	46	4300	41.0	66	720.0	89	960.0	240.0	1.370	0	.	.	.
8	10	18100	3200.0	26	3000	27.0	82	575.0	69	820.0	460.0	1.298	0	.	.	.
8	10	17000	3200.0	32	4800	33.0	73	760.0	82	850.0	480.0	1.348	0	.	.	.
8	11	21000	4100.0	36	5700	68.0	58	830.0	140	1100.0	800.0	1.148	0	.	.	.
8	11	17000	5600.0	34	5300	69.0	60	690.0	140	1100.0	540.0	1.102	0	.	.	.
8	11	18000	5100.0	26	3800	78.0	54	470.0	100	930.0	430.0	1.127	0	.	.	.
8	12	18000	5900.0	35	3400	102.0	61	720.0	150	1300.0	330.0	1.321	0	.	.	.
8	12	19000	4800.0	35	4500	64.0	45	680.0	160	1200.0	410.0	1.106	0	.	.	.
8	12	16000	2800.0	25	3800	47.0	32	580.0	120	660.0	340.0	1.205	0	.	.	.
8	13	18000	7200.0	22	3500	46.0	78	540.0	110	1000.0	330.0	1.314	0	.	.	.
8	13	23000	7600.0	41	4100	67.0	55	780.0	160	1700.0	400.0	1.084	0	.	.	.
8	13	21000	4900.0	24	4000	48.0	53	570.0	110	1100.0	360.0	0.985	0	.	.	.
8	14	18700	11800.0	34	3600	53.0	80	600.0	140	1300.0	350.0	1.159	0	.	.	.
8	14	16500	5600.0	39	3300	72.0	100	700.0	160	1400.0	310.0	1.238	0	.	.	.
8	14	16000	5000.0	27	3600	53.0	62	650.0	140	1100.0	300.0	1.185	0	.	.	.
8	15	17600	9700.0	36	3700	74.0	150	600.0	180	2000.0	310.0	1.025	0	.	.	.
8	15	17400	9600.0	36	2400	71.0	140	530.0	150	1900.0	280.0	1.014	0	.	.	.
8	15	18000	12000.0	38	3400	84.0	97	790.0	180	2000.0	330.0	1.033	0	.	.	.
8	16	10000	2600.0	26	2400	35.0	82	440.0	95	530.0	210.0	2.046	0	.	.	.

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	MAGNES	MANGAN	MOLY	SODIUM	NICKL	LEAD	TITAN	VANA	ZINC	BARIUM	TRNSF	FIRE	NEED	LOI	H2O
8	16	13000	3100.0	29	2900	44.0	96	510.0	110	560.0	250.0	1.717	0	.	.	.
8	16	13000	3000.0	30	2000	41.0	120	450.0	100	590.0	250.0	1.918	0	.	.	.
8	17	16000	2700.0	10	5100	30.0	80	745.0	76	780.0	505.0	1.400	0	.	.	.
8	17	20000	1900.0	2	4900	27.0	73	540.0	69	600.0	660.0	1.300	0	.	.	.
8	17	17000	1500.0	23	7900	34.0	61	820.0	86	760.0	620.0	1.300	0	.	.	.
8	18	19000	4700.0	2	5300	45.0	80	740.0	95	1050.0	400.0	1.200	0	.	.	.
8	18	26000	6200.0	11	5300	53.0	110	780.0	95	1400.0	470.0	1.000	0	.	.	.
8	18	27000	6500.0	30	6600	85.0	110	650.0	100	1500.0	560.0	1.100	0	.	.	.
8	19	32000	3600.0	26	2500	36.0	87	390.0	79	1100.0	360.0	0.900	0	.	.	.
8	19	30000	6500.0	26	3000	37.0	100	450.0	85	1300.0	950.0	0.800	0	.	.	.
8	19	26000	6300.0	27	2800	34.0	133	560.0	83	1100.0	940.0	0.900	0	.	.	.
8	20	29000	5300.0	21	3300	37.0	140	360.0	71	1200.0	760.0	0.800	0	.	.	.
8	20	31000	6300.0	24	4200	48.0	83	310.0	84	1700.0	530.0	0.800	0	.	.	.
8	20	33000	3100.0	26	3300	50.0	140	460.0	85	1400.0	560.0	0.900	0	.	.	.
9	1	42200	9400.0	.	2700	26.0	69	140.0	51	780.0	370.0	2.743	0	.	.	.
9	1	45200	13000.0	.	2500	27.0	58	160.0	65	1000.0	350.0	2.473	0	.	.	.
9	1	32000	16700.0	.	2300	22.0	35	220.0	49	1300.0	330.0	2.928	0	.	.	.
9	2	33100	5900.0	.	3600	26.0	70	530.0	52	680.0	630.0	2.080	0	.	.	.
9	2	29900	7400.0	.	3000	28.0	79	140.0	56	880.0	370.0	2.136	0	.	.	.
9	2	33500	6700.0	.	3100	25.0	2	46.0	44	770.0	64.0	2.352	0	.	.	.
10	1	15000	3300.0	.	2800	37.0	140	720.0	82	1400.0	210.0	1.121	0	.	.	.
10	1	16000	5400.0	.	3000	41.0	150	650.0	82	1400.0	330.0	0.898	0	.	.	.
10	1	20000	6100.0	.	3100	41.0	120	530.0	73	1100.0	220.0	0.902	0	.	.	.
10	2	17000	2400.0	.	3400	60.0	200	940.0	83	1200.0	580.0	0.518	0	.	.	.
10	2	18000	2500.0	.	5100	190.0	120	920.0	95	1200.0	400.0	1.022	0	.	.	.
10	2	19000	2500.0	.	3500	53.0	120	970.0	88	1300.0	300.0	0.523	0	.	.	.
10	5	16400	1800.0	28	5100	37.0	100	650.0	82	920.0	460.0	1.072	0	.	.	.
10	5	18000	2700.0	33	4300	40.0	110	780.0	91	1100.0	520.0	1.138	0	.	.	.
10	5	18400	2500.0	44	3000	49.0	330	810.0	110	1500.0	500.0	1.127	0	.	.	.
10	6	17000	2400.0	32	4700	120.0	110	760.0	86	850.0	520.0	1.122	0	.	.	.
10	6	13000	1600.0	27	3200	41.0	150	620.0	80	710.0	410.0	1.326	0	.	.	.
10	6	15000	1900.0	26	3300	29.0	100	620.0	74	720.0	430.0	1.174	0	.	.	.
10	7	14000	1800.0	28	3200	37.0	200	655.0	82	690.0	440.0	1.209	0	.	.	.
10	7	17000	1800.0	35	3200	36.0	150	740.0	88	850.0	450.0	1.206	0	.	.	.
10	7	17000	2700.0	46	3200	50.0	260	880.0	120	1200.0	470.0	1.290	0	.	.	.
10	8	12000	2400.0	30	3200	34.0	140	700.0	89	800.0	420.0	1.366	0	.	.	.
10	8	15000	2300.0	34	4600	88.0	110	790.0	91	800.0	500.0	1.302	0	.	.	.
10	8	14400	2400.0	29	4600	32.0	120	710.0	86	780.0	480.0	1.197	0	.	.	.
10	9	14000	1400.0	33	2700	34.0	100	780.0	87	840.0	590.0	1.242	0	.	.	.
10	9	14900	2200.0	48	2800	43.0	170	880.0	110	1200.0	550.0	1.324	0	.	.	.
10	9	15400	2200.0	39	2500	43.0	150	800.0	100	1300.0	510.0	1.202	0	.	.	.
10	10	13000	2000.0	26	2550	27.0	103	640.0	74	650.0	350.0	1.432	0	.	.	.
10	10	13000	2700.0	27	2600	30.0	90	600.0	72	650.0	330.0	1.383	0	.	.	.
10	10	15000	3000.0	32	4700	34.0	95	820.0	92	860.0	440.0	1.441	0	.	.	.
10	15	26000	5600.0	38	4200	79.0	120	790.0	180	1600.0	370.0	1.023	0	.	.	.
10	15	15000	4900.0	33	5000	73.0	120	710.0	170	1200.0	330.0	1.032	0	.	.	.
10	15	11300	3000.0	27	3700	57.0	97	580.0	140	820.0	280.0	1.421	0	.	.	.
10	21	35000	10000.0	27	3400	50.0	110	640.0	88	1900.0	710.0	0.500	0	.	.	.
10	21	40000	12000.0	24	2600	38.0	73	380.0	81	2400.0	420.0	0.400	0	.	.	.
10	21	33000	11000.0	24	3600	37.0	24	630.0	86	2000.0	780.0	0.500	0	.	.	.
10	22	26000	5600.0	24	3300	36.0	66	460.0	78	1300.0	650.0	0.700	0	.	.	.
10	22	25000	11000.0	19	3700	38.0	85	460.0	76	1500.0	630.0	0.500	0	.	.	.
10	22	24000	9300.0	21	5000	32.0	75	450.0	86	1400.0	690.0	0.600	0	.	.	.
11	5	71700	6800.0	13	860	81.0	15	100.0	28	11500.0	560.0	1.128	0	.	.	.
11	6	57900	4500.0	17	520	75.0	2	30.0	25	5600.0	98.0	1.475	0	.	.	.

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	MAGNES	MANGAN	MOLY	SODIUM	NICKL	LEAD	TITAN	VANA	ZINC	BARIUM	TRNSF	FIRE	NEED	LOI	H2O
11	7	58800	11200.0	17	570	97.0	13	59.0	31	6500.0	730.0	1.239	0	.	.	.
11	17	57000	16000.0	22	730	85.0	11	66.0	33	7300.0	790.0	1.600	0	.	.	.
11	17	43000	19000.0	14	550	51.0	8	35.0	19	7400.0	770.0	2.200	0	.	.	.
11	17	39000	7500.0	15	510	28.0	4	38.0	18	4800.0	1200.0	2.300	0	.	.	.
11	18	41000	23000.0	15	670	180.0	53	79.0	27	8000.0	1100.0	1.600	0	.	.	.
11	18	48000	11000.0	10	4600	160.0	160	90.0	25	5700.0	6200.0	1.400	0	.	.	.
11	18	49000	24000.0	40	910	150.0	19	79.0	32	8100.0	3000.0	1.500	0	.	.	.
11	19	45000	6300.0	14	790	40.0	40	49.0	23	4700.0	6900.0	1.500	0	.	.	.
11	19	69000	7200.0	19	400	47.0	11	50.0	27	6600.0	1300.0	1.400	0	.	.	.
11	19	73000	8300.0	25	600	21.0	5	55.0	23	7200.0	850.0	1.200	0	.	.	.
11	20	45000	6600.0	14	740	58.0	20	42.0	20	8400.0	1350.0	1.700	0	.	.	.
11	20	64000	8000.0	22	750	76.0	24	56.0	28	22000.0	1200.0	1.400	0	.	.	.
11	20	54000	6800.0	12	520	310.0	17	37.0	19	6400.0	1300.0	1.700	0	.	.	.
11	21	50000	13000.0	37	530	39.0	36	22.0	26	8800.0	2300.0	1.600	0	.	.	.
11	21	51000	12000.0	23	330	58.0	56	16.0	24	8300.0	3200.0	1.400	0	.	.	.
11	21	36000	8000.0	11	400	26.0	84	18.0	18	7000.0	1400.0	1.900	0	.	.	.
11	22	66000	7800.0	10	950	83.0	15	55.0	20	7600.0	3100.0	1.300	0	.	.	.
11	22	58000	20000.0	17	910	64.0	30	64.0	26	14000.0	2700.0	1.300	0	.	.	.
11	22	63000	15000.0	21	760	65.0	27	94.0	34	14000.0	2200.0	1.200	0	.	.	.
12	6	15000	2500.0	28	4900	41.0	140	590.0	74	1400.0	560.0	1.066	0	.	.	.
12	6	14900	1800.0	33	5600	40.0	110	640.0	77	1300.0	400.0	1.089	0	.	.	.
12	6	13000	2300.0	46	4600	47.0	160	890.0	100	2000.0	350.0	1.253	0	.	.	.
12	7	14000	2200.0	24	5200	74.0	77	500.0	58	860.0	330.0	1.170	0	.	.	.
12	7	14000	1500.0	27	3500	37.0	110	560.0	69	880.0	340.0	1.197	0	.	.	.
12	7	17500	2500.0	39	3400	49.0	130	670.0	87	1400.0	420.0	1.189	0	.	.	.
12	8	13500	3700.0	43	2700	54.0	180	670.0	95	2100.0	340.0	1.258	0	.	.	.
12	8	14300	3400.0	38	3000	44.0	180	680.0	91	1800.0	380.0	1.220	0	.	.	.
12	8	13500	2300.0	40	3500	50.0	140	700.0	92	1600.0	340.0	1.251	0	.	.	.
12	9	14200	2100.0	53	3900	72.0	84	820.0	110	3000.0	460.0	1.090	0	.	.	.
12	9	14300	2000.0	31	4800	45.0	69	640.0	66	1700.0	660.0	1.150	0	.	.	.
12	9	15000	1900.0	43	2700	52.0	61	670.0	90	3000.0	320.0	1.082	0	.	.	.
13	8	64000	22000.0	25	500	55.0	8	130.0	46	570.0	1000.0	2.527	0	.	.	.
13	8	63000	13000.0	15	700	28.0	15	120.0	31	520.0	1300.0	2.449	0	.	.	.
13	8	67000	16000.0	15	1200	40.0	9	180.0	28	480.0	1000.0	2.797	0	.	.	.
13	9	60000	13000.0	12	820	62.0	18	140.0	29	530.0	1400.0	2.881	0	.	.	.
13	9	63000	14000.0	15	1400	58.0	6	150.0	30	420.0	740.0	2.559	0	.	.	.
13	9	55000	10000.0	17	860	94.0	13	170.0	33	540.0	680.0	2.834	0	.	.	.
13	21	84000	12000.0	17	630	49.0	3	17.0	32	520.0	675.0	2.500	0	.	.	.
13	21	67500	16500.0	16	330	34.0	7	15.0	28	560.0	670.0	3.000	0	.	.	.
13	21	67000	10500.0	18	260	26.0	6	12.0	26	590.0	505.0	2.000	0	.	.	.
13	22	67000	11000.0	14	390	128.0	2	48.0	29	620.0	735.0	2.400	0	.	.	.
13	22	72500	17500.0	14	760	53.0	44	55.0	28	450.0	1080.0	2.200	0	.	.	.
13	22	70000	18000.0	12	560	88.0	13	100.0	40	600.0	4500.0	2.100	0	.	.	.
14	9	24000	6500.0	22	11000	44.0	130	710.0	62	1400.0	1700.0	0.896	0	.	.	.
14	9	21400	6900.0	40	7500	52.0	150	760.0	87	2400.0	610.0	1.362	0	.	.	.
14	9	27000	7800.0	35	11000	45.0	59	740.0	74	1800.0	230.0	1.308	0	.	.	.
15	11	36800	900.0	40	220	5.0	8	3.0	36	2600.0	310.0	3.005	0	.	.	.
15	11	50200	1300.0	8	220	8.0	2	11.0	18	2000.0	1100.0	3.340	0	.	.	.
15	11	30600	4800.0	11	150	8.0	2	10.0	21	3000.0	710.0	4.007	0	.	.	.
16	16	40600	2100.0	8	710	7.0	2	9.0	21	1700.0	730.0	3.807	0	.	.	.
16	16	50400	700.0	22	380	29.0	13	61.0	39	600.0	730.0	2.873	0	.	.	.
16	16	55000	700.0	14	440	13.0	9	94.0	30	770.0	1400.0	3.062	0	.	.	.
16	17	46000	820.0	12	1000	19.0	9	99.0	25	1300.0	460.0	2.900	0	.	.	.
16	17	36000	1900.0	10	560	13.0	3	41.0	19	2200.0	620.0	2.900	0	.	.	.
20	22	48000	22000.0	15	340	80.0	2	26.0	24	2500.0	540.0	2.500	0	.	.	.

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	MAGNES	MANGAN	MOLY	SODIUM	NICKL	LEAD	TITAN	VANA	ZINC	BARIUM	TRNSF	FIRE	NEED	LOI	H2O
20	22	49000	15000.0	13	440	72.0	2	0.5	20	2500.0	52.0	2.6	0	.	.	.
20	22	46000	18000.0	18	710	77.0	9	28.0	26	2000.0	460.0	2.3	0	.	.	.
21	17	25000	5200.0	33	270	49.0	26	24.0	15	510.0	1300.0	3.4	0	.	.	.
21	17	19000	4400.0	16	300	24.0	14	26.0	12	435.0	1900.0	3.7	0	.	.	.
21	17	22000	4600.0	15	260	15.0	19	18.0	15	460.0	1400.0	3.8	0	.	.	.
22	1	300	<0.2	.	130	5.0	2	78.0	6	<0.2	19.0	1.0	0	.	.	.
22	1	700	100.0	.	110	12.0	2	100.0	6	10.0	18.0	1.0	0	.	.	.
22	1	1200	<0.2	.	100	11.0	2	250.0	13	10.0	21.0	1.0	0	.	.	.
22	1	420	19.0	5	270	11.0	5	100.0	6	2.2	15.0	.	0	.	1.80	0.34
22	1	500	16.0	4	220	2.4	9	93.0	5	2.5	11.0	.	0	.	0.79	0.24
22	1	510	18.0	4	290	4.0	3	85.0	6	1.4	16.0	.	0	.	1.10	0.37
22	2	1400	<0.2	.	100	5.0	2	690.0	26	10.0	22.0	1.0	0	.	.	.
22	2	1300	<0.2	.	90	5.0	2	480.0	16	10.0	19.0	1.0	0	.	.	.
22	2	600	<0.2	.	110	7.0	2	650.0	12	<0.2	18.0	1.0	0	.	.	.
22	2	460	48.0	7	470	12.0	8	340.0	9	8.6	150.0	.	0	.	48.70	6.10
22	2	570	44.0	7	740	11.0	4	340.0	10	7.8	64.0	.	0	.	22.70	12.9
22	2	350	37.0	8	460	14.0	7	290.0	11	7.5	120.0	.	0	.	43.10	6.80
22	5	410	32.0	7	490	20.0	13	300.0	9	20.0	160.0	.	0	.	69.10	40
22	5	390	51.0	9	930	18.0	9	500.0	15	13.0	120.0	.	0	.	29.80	30.7
22	5	1000	42.0	9	620	84.0	14	530.0	15	34.0	210.0	.	0	.	58.70	45.5
22	6	520	38.0	6	960	8.5	4	270.0	11	8.2	48.0	.	0	.	8.20	5.40
22	6	440	49.0	5	1000	8.7	10	230.0	13	5.4	41.0	.	0	.	8.50	6.50
22	6	380	57.0	7	820	16.0	9	280.0	12	12.0	100.0	.	0	.	23.30	16.2
22	7	1800	72.0	9	360	5.3	6	670.0	23	9.0	28.0	.	0	.	4.20	1.80
22	7	1200	70.0	6	410	5.5	3	920.0	22	7.2	31.0	.	0	.	4.30	1.30
22	7	1400	47.0	7	360	6.1	5	490.0	16	7.8	24.0	.	0	.	3.60	0.72
22	8	1400	49.0	7	780	8.4	5	360.0	13	8.0	27.0	.	0	.	2.30	0.57
22	8	300	34.0	5	770	6.7	6	180.0	6	4.2	27.0	.	0	.	1.70	0.47
22	8	1000	40.0	8	540	4.4	6	380.0	14	8.2	38.0	.	0	.	2.90	1.50
22	9	520	43.0	5	710	8.0	5	480.0	14	4.3	36.0	.	0	.	4.90	3.40
22	9	1000	44.0	7	600	6.1	9	540.0	16	7.0	27.0	.	0	.	2.90	3.20
22	9	530	33.0	4	730	4.6	5	320.0	10	3.2	22.0	.	0	.	2.80	2.20
22	10	1700	59.0	8	340	6.7	12	540.0	17	9.5	43.0	.	0	.	17.70	8.10
22	10	1000	51.0	8	460	11.0	16	390.0	15	12.0	70.0	.	0	.	40.80	22
22	10	920	46.0	6	320	6.0	12	340.0	11	11.0	60.0	.	0	.	41.50	31.6
22	11	45	15.0	2	230	4.0	4	29.0	5	0.9	7.9	.	0	.	0.41	0.09
22	11	19	10.0	2	200	5.9	2	12.0	5	0.5	5.9	.	0	.	0.24	0.08
22	11	78	88.0	2	220	4.8	4	39.0	5	1.7	11.0	.	0	.	0.38	0.10
22	12	48	18.0	2	210	4.9	3	48.0	5	0.6	11.0	.	0	.	0.47	0.11
22	12	49	13.0	2	220	5.4	2	37.0	5	1.4	7.8	.	0	.	0.27	0.11
22	12	42	12.0	2	250	6.2	10	29.0	5	1.1	7.7	.	0	.	0.40	0.11
22	12	59	64.0	2	98	5.9	5	15.0	5	4.5	15.0	.	1	.	1.10	0.26
22	12	50	33.0	2	80	5.1	8	13.0	5	3.5	16.0	.	1	.	1.50	0.23
22	12	48	52.0	2	40	7.4	6	13.0	5	5.8	15.0	.	1	.	2.90	0.27
22	13	34	12.0	2	70	6.8	2	21.0	5	0.5	6.8	.	0	.	0.65	0.15
22	13	37	15.0	2	90	6.1	2	46.0	5	2.2	8.3	.	0	.	1.00	0.13
22	13	49	14.0	2	80	5.7	6	43.0	5	2.6	8.4	.	0	.	1.40	0.15
22	13	110	46.0	2	70	9.1	6	35.0	5	6.0	23.0	.	1	.	7.40	0.72
22	13	100	85.0	2	120	7.8	7	41.0	5	9.0	39.0	.	1	.	7.30	0.48
22	13	66	42.0	2	60	8.9	6	16.0	5	7.7	22.0	.	1	.	5.60	0.39
22	14	32	9.0	2	120	3.7	2	20.0	5	1.8	10.0	.	0	.	1.60	0.21
22	14	31	10.0	2	50	4.4	2	16.0	5	2.3	6.4	.	0	.	1.30	0.22
22	14	39	78.0	2	70	7.6	2	24.0	5	3.2	13.0	.	0	.	3.40	0.65
22	14	55	39.0	2	230	5.4	3	22.0	5	5.2	9.5	.	1	.	2.40	0.15
22	14	64	24.0	2	250	6.4	3	27.0	5	3.4	10.0	.	1	.	1.30	0.11

ORIGINAL VEGETATION AND SOIL DATA

SPEC	LOC	MAGNES	MANGAN	MOLY	SODIUM	NICKL	LEAD	TITAN	VANA	ZINC	BARIUM	TRNSF	FIRE	NEED	LOI	H2O
22	14	96	57.0	2	250	6.9	5	28.0	5	7.7	23.0	.	1	.	6.20	0.71
22	15	60	19.0	2	40	2.3	4	19.0	5	2.5	11.0	.	0	.	1.60	0.28
22	15	48	19.0	2	50	4.0	2	20.0	5	1.1	8.7	.	0	.	0.61	0.17
22	15	71	38.0	2	70	6.7	5	23.0	5	4.6	14.0	.	0	.	2.70	0.47
22	15	88	48.0	2	60	6.2	4	18.0	5	9.6	20.0	.	1	.	8.50	0.70
22	15	56	31.0	2	210	4.1	8	25.0	5	4.9	13.0	.	1	.	1.80	0.23
22	15	82	80.0	3	220	8.4	4	21.0	5	9.2	24.0	.	1	.	5.80	0.58
22	16	74	41.0	2	80	7.8	10	35.0	5	26.0	13.0	.	0	.	1.10	0.11
22	16	100	36.0	2	80	5.4	4	52.0	5	3.8	19.0	.	0	.	1.90	0.27
22	16	54	43.0	2	90	3.9	8	27.0	5	3.4	16.0	.	0	.	1.20	0.25
22	16	56	11.0	2	110	3.3	2	38.0	5	0.5	8.8	.	1	.	0.44	0.07
22	16	35	11.0	2	78	4.1	2	26.0	5	0.5	6.5	.	1	.	0.41	0.09
22	16	60	16.0	2	96	4.1	2	31.0	5	1.3	8.7	.	1	.	0.60	0.11
22	17	1500	88.0	9	170	11.0	30	330.0	22	34.0	100.0	.	0	.	14.70	.
22	17	5100	220.0	15	210	25.0	32	710.0	33	86.0	98.0	.	0	.	8.50	.
22	17	1900	85.0	7	200	12.0	11	370.0	23	29.0	68.0	.	0	.	3.40	.
22	18	1900	980.0	21	150	35.0	76	580.0	67	62.0	76.0	.	0	.	9.40	.
22	18	1400	61.0	11	150	9.0	18	660.0	37	25.0	53.0	.	0	.	6.00	.
22	18	1400	170.0	13	140	28.0	28	480.0	27	57.0	100.0	.	0	.	12.20	.
22	19	560	40.0	3	390	6.0	11	370.0	10	29.0	17.0	.	0	.	1.40	.
22	19	670	50.0	4	260	45.0	16	480.0	19	16.0	45.0	.	0	.	4.80	.
22	19	290	23.0	2	240	18.0	12	230.0	5	22.0	18.0	.	0	.	1.20	.
22	20	1600	62.0	6	340	30.0	13	530.0	19	22.0	26.0	.	0	.	3.10	.
22	20	1200	53.0	5	270	15.0	16	370.0	13	15.0	21.0	.	0	.	2.80	.
22	20	440	28.0	4	240	7.0	5	270.0	12	29.0	18.0	.	0	.	2.70	.
22	21	2000	130.0	5	240	8.0	13	560.0	17	20.0	46.0	.	0	.	1.80	.
22	21	1200	55.0	4	200	7.0	14	380.0	11	12.0	39.0	.	0	.	4.80	.
22	21	1600	77.0	6	220	9.0	11	690.0	20	12.0	35.0	.	0	.	4.30	.
22	22	880	43.0	2	270	9.0	3	440.0	11	10.0	22.0	.	0	.	5.10	.
22	22	580	33.0	2	240	8.0	8	540.0	13	13.0	20.0	.	0	.	4.40	.
22	22	2700	89.0	5	330	13.0	17	880.0	22	20.0	31.0	.	0	.	4.70	.

Appendix 8.4.1 Summary tables for stable elements, regional means. Elements in alphabetical order.

Species codes

1 Vaccinium myrtilloides
2 Pinus banksiana
3 Ledum groenlandicum
4 Alnus crispa
5 Vaccinium vitis-idaea
6 Picea mariana
7 Cladina rangiferina
8 Cladina mitis
9 Pleurozium schreberi
10 Cladina stellaris
11 Betula neoalaskana
12 Stereocaulon paschale
13 Empetrum nigrum
14 Cetraria nivalis
15 Populus tremuloides
16 Arctostaphyllos uva-ursi
20 Vaccinium uliginosum
21 Juniperus communis
29 Pinus banksiana (needles)
69 Picea mariana (needles)
22 Soil

Locality codes

Wollaston Bay region

1 Hidden Bay
2 Collins Creek
5 Hungry Island
6 Cunning Bay
7 Parks Lake
8 Labach Lake
9 Midwest Lake
10 Minor Bay

Cluff Lake region

11 Carswell Lake
12 South Gate
13 Carswell North
14 Jolley Lake
15 Sandy Lake
16 Mill Site

N. Sask./N.W.T.

17 Uranium City
18 Eagle Lake
19 Tazin River
20 Ena Lake
21 McInnes Lake
22 Dunvegan Lake

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

ALUMINUM: Grand mean= 180.76 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	383.46	-	-	383.46	141.36
	6	46.65	-	50.46	48.55	141.36
	11	35.24	-	26.30	30.77	141.36
	15	-	42.52	-	42.52	141.36
	2n	-	501.44	439.42	470.43	141.36
	6n	55.19	58.02	41.13	51.45	141.36
SHRUBS	1	162.86	198.75	-	180.80	101.02
	3	104.01	-	63.76	83.89	101.02
	4	112.66	54.63	33.53	66.94	101.02
	5	157.38	207.64	110.71	158.58	101.02
	13	145.01	-	52.12	98.56	101.02
	16	-	120.73	94.25	107.49	101.02
	20	-	-	78.47	78.47	101.02
	21	-	-	33.45	33.45	101.02
LICHENS	7	254.61	-	102.00	178.30	269.84
	8	310.41	353.27	236.08	299.92	269.84
	10	381.58	337.73	95.67	271.66	269.84
	12	291.59	-	-	291.59	269.84
	14	307.71	-	-	307.71	269.84
MOSSES	9	314.79	-	-	314.79	314.79
SOIL		6314.58	630.00	8183.33	5042.64	5042.64
REGION MEAN		182.82	306.28	127.60		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

BARIUM: Grand mean= 13.200 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	10.052	-	-	10.052	17.408
	6	19.822	-	13.954	16.888	17.408
	11	5.602	-	33.907	19.755	17.408
	15	-	24.835	-	24.835	17.408
	2n	-	7.220	7.713	7.467	17.408
	6n	15.668	13.913	22.480	17.354	17.408
SHRUBS	1	11.103	17.159	-	14.131	22.073
	3	15.684	-	14.899	15.292	22.073
	4	10.799	17.441	35.196	21.145	22.073
	5	11.629	8.837	8.498	9.655	22.073
	13	27.270	-	30.496	28.883	22.073
	16	-	30.544	15.660	23.102	22.073
	20	-	-	8.477	8.477	22.073
	21	-	-	55.900	55.900	22.073
LICHENS	7	4.876	-	4.973	4.925	5.541
	8	4.765	4.414	6.169	5.116	5.541
	10	5.009	3.723	3.495	4.076	5.541
	12	4.739	-	-	4.739	5.541
	14	8.850	-	-	8.850	5.541
MOSSES	9	8.497	-	-	8.497	8.497
SOIL		56.604	10.328	46.278	37.737	37.737
REGION MEAN		10.655	9.833	15.677		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

BERYLL: Grand mean= 0.024 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	0.023	-	-	0.023	0.014
	6	0.018	-	0.010	0.014	0.014
	11	0.008	-	0.009	0.008	0.014
	15	-	0.017	-	0.017	0.014
	2n	-	0.016	0.011	0.014	0.014
	6n	0.011	0.014	0.011	0.012	0.014
SHRUBS	1	0.016	0.017	-	0.016	0.018
	3	0.016	-	0.013	0.014	0.018
	4	0.038	0.018	0.021	0.026	0.018
	5	0.013	0.016	0.013	0.014	0.018
	13	0.024	-	0.014	0.019	0.018
	16	-	0.026	0.020	0.023	0.018
	20	-	-	0.012	0.012	0.018
	21	-	-	0.018	0.018	0.018
LICHENS	7	0.048	-	0.008	0.028	0.048
	8	0.049	0.054	0.034	0.046	0.048
	10	0.066	0.057	0.008	0.044	0.048
	12	0.062	-	-	0.062	0.048
	14	0.060	-	-	0.060	0.048
MOSSES	9	0.046	-	-	0.046	0.046
SOIL		2.144	0.678	2.028	1.616	1.616
REGION MEAN		0.030	0.029	0.017		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

BORON: Grand mean= 7.28 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	9.28	-	-	9.28	8.40
	6	6.90	-	5.58	6.24	8.40
	11	4.35	-	9.84	7.10	8.40
	15	-	11.08	-	11.08	8.40
	2n	-	9.92	4.91	7.42	8.40
	6n	3.78	12.59	4.11	6.82	8.40
SHRUBS	1	9.73	30.70	-	20.22	10.95
	3	10.90	-	13.03	11.97	10.95
	4	6.75	8.60	7.30	7.55	10.95
	5	7.31	11.99	8.39	9.23	10.95
	13	12.42	-	9.93	11.18	10.95
	16	-	6.65	7.11	6.88	10.95
	20	-	-	9.83	9.83	10.95
	21	-	-	10.72	10.72	10.95
LICHENS	7	0.37	-	0.54	0.45	0.36
	8	0.29	0.34	0.32	0.32	0.36
	10	0.30	0.26	0.23	0.26	0.36
	12	0.58	-	-	0.58	0.36
	14	0.17	-	-	0.17	0.36
MOSSES	9	1.30	-	-	1.30	1.30
SOIL		44.94	38.33	5.22	29.50	29.50
REGION MEAN		4.50	9.92	5.61		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

CADMIUM: Grand mean= 0.089 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	0.194	-	-	0.194	0.187
	6	0.023	-	0.012	0.017	0.187
	11	0.267	-	0.371	0.319	0.187
	15	-	0.269	-	0.269	0.187
	2n	-	0.147	0.095	0.121	0.187
	6n	0.012	0.015	0.014	0.014	0.187
SHRUBS	1	0.034	0.043	-	0.038	0.186
	3	0.024	-	0.015	0.020	0.186
	4	0.029	0.020	0.028	0.026	0.186
	5	0.040	0.037	0.018	0.032	0.186
	13	0.025	-	0.014	0.019	0.186
	16	-	0.016	0.015	0.015	0.186
	20	-	-	1.310	1.310	0.186
	21	-	-	0.030	0.030	0.186
LICHENS	7	0.128	-	0.050	0.089	0.123
	8	0.128	0.082	0.066	0.092	0.123
	10	0.135	0.071	0.038	0.082	0.123
	12	0.188	-	-	0.188	0.123
	14	0.165	-	-	0.165	0.123
MOSSES	9	0.200	-	-	0.200	0.200
SOIL		0.500	0.500	0.828	0.609	0.609
REGION MEAN		0.090	0.077	0.101		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

CALCIUM: Grand mean= 4277.46 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	3673.40	-	-	3673.40	5760.25
	6	4726.68	-	3910.56	4318.62	5760.25
	11	2708.86	-	3347.28	3028.07	5760.25
	15	-	10040.27	-	10040.27	5760.25
	2n	-	5719.77	3715.42	4717.59	5760.25
	6n	4993.08	6874.51	5764.00	5877.20	5760.25
SHRUBS	1	5550.39	6383.28	-	5966.83	6253.33
	3	6597.27	-	5334.17	5965.72	6253.33
	4	3685.79	8262.17	5169.83	5705.93	6253.33
	5	7051.60	7994.38	5205.56	6750.51	6253.33
	13	5642.28	-	4864.33	5253.31	6253.33
	16	-	9305.32	6090.00	7697.66	6253.33
	20	-	-	3713.33	3713.33	6253.33
	21	-	-	8973.33	8973.33	6253.33
LICHENS	7	580.05	-	591.67	585.86	663.31
	8	548.45	538.15	615.50	567.37	663.31
	10	377.38	341.98	377.33	365.57	663.31
	12	362.53	-	-	362.53	663.31
	14	1435.23	-	-	1435.23	663.31
MOSSES	9	2223.67	-	-	2223.67	2223.67
SOIL		756.25	112.56	1305.56	724.79	724.79
REGION MEAN		3604.89	4728.78	3310.62		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

CHROMIUM: Grand mean= 0.324 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	0.726	-	-	0.726	0.273
	6	0.290	-	0.152	0.221	0.273
	11	0.157	-	0.096	0.127	0.273
	15	-	0.322	-	0.322	0.273
	2n	-	0.414	0.200	0.307	0.273
	6n	0.237	0.224	0.093	0.185	0.273
SHRUBS	1	0.373	0.629	-	0.501	0.254
	3	0.299	-	0.120	0.209	0.254
	4	0.374	0.252	0.159	0.262	0.254
	5	0.311	0.389	0.166	0.289	0.254
	13	0.292	-	0.145	0.218	0.254
	16	-	0.290	0.087	0.188	0.254
	20	-	-	0.115	0.115	0.254
	21	-	-	0.248	0.248	0.254
LICHENS	7	0.437	-	0.157	0.297	0.434
	8	0.435	0.518	0.332	0.428	0.434
	10	0.610	0.443	0.157	0.403	0.434
	12	0.575	-	-	0.575	0.434
	14	0.469	-	-	0.469	0.434
MOSSES	9	0.587	-	-	0.587	0.587
SOIL		234.206	218.889	96.889	183.328	183.328
REGION MEAN		0.381	0.450	0.180		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

COBALT: Grand mean= 0.099 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	0.101	-	-	0.101	0.129
	6	0.022	-	0.118	0.070	0.129
	11	0.089	-	0.278	0.184	0.129
	15	-	0.164	-	0.164	0.129
	2n	-	0.061	0.244	0.152	0.129
	6n	0.019	0.017	0.059	0.032	0.129
SHRUBS	1	0.048	0.044	-	0.046	0.089
	3	0.035	-	0.044	0.039	0.089
	4	0.441	0.121	0.512	0.358	0.089
	5	0.035	0.020	0.056	0.037	0.089
	13	0.059	-	0.043	0.051	0.089
	16	-	0.060	0.028	0.044	0.089
	20	-	-	0.058	0.058	0.089
	21	-	-	0.083	0.083	0.089
LICHENS	7	0.104	-	0.035	0.070	0.099
	8	0.090	0.098	0.097	0.095	0.099
	10	0.108	0.103	0.039	0.083	0.099
	12	0.101	-	-	0.101	0.099
	14	0.149	-	-	0.149	0.099
MOSSES	9	0.115	-	-	0.115	0.115
SOIL		2.035	0.633	7.556	3.408	3.408
REGION MEAN		0.076	0.069	0.135		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

COPPER: Grand mean= 2.870 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	2.094	-	-	2.094	2.866
	6	2.087	-	1.846	1.966	2.866
	11	3.683	-	4.660	4.171	2.866
	15	-	3.839	-	3.839	2.866
	2n	-	1.405	1.927	1.666	2.866
	6n	1.230	1.373	2.228	1.611	2.866
SHRUBS	1	5.401	5.077	-	5.239	4.210
	3	3.934	-	4.118	4.026	4.210
	4	5.520	4.203	7.395	5.706	4.210
	5	4.057	3.653	3.676	3.796	4.210
	13	4.353	-	3.929	4.141	4.210
	16	-	2.195	2.770	2.482	4.210
	20	-	-	5.987	5.987	4.210
	21	-	-	2.302	2.302	4.210
LICHENS	7	0.744	-	0.903	0.824	0.747
	8	0.637	0.595	0.613	0.615	0.747
	10	0.665	0.599	0.350	0.538	0.747
	12	1.182	-	-	1.182	0.747
	14	0.579	-	-	0.579	0.747
MOSSES	9	2.733	-	-	2.733	2.733
SOIL		8.352	3.917	11.611	7.960	7.960
REGION MEAN		2.406	2.139	2.762		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

IRON: Grand mean= 84.189 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	56.972	-	-	56.972	30.342
	6	25.110	-	23.089	24.099	30.342
	11	28.046	-	28.461	28.254	30.342
	15	-	18.378	-	18.378	30.342
	2n	-	56.788	36.104	46.446	30.342
	6n	24.696	26.390	23.325	24.804	30.342
SHRUBS	1	75.169	95.373	-	85.271	47.904
	3	48.803	-	35.504	42.154	47.904
	4	64.480	49.803	39.685	51.323	47.904
	5	35.349	44.191	29.158	36.233	47.904
	13	84.718	-	29.150	56.934	47.904
	16	-	51.063	52.200	51.631	47.904
	20	-	-	27.147	27.147	47.904
	21	-	-	32.543	32.543	47.904
LICHENS	7	182.935	-	68.717	125.826	177.372
	8	186.383	216.664	167.167	190.071	177.372
	10	234.627	216.984	65.700	172.437	177.372
	12	231.360	-	-	231.360	177.372
	14	167.167	-	-	167.167	177.372
MOSSES	9	203.810	-	-	203.810	203.810
SOIL		6189.583	1994.444	8227.778	5470.602	5470.602
REGION MEAN		103.558	111.581	64.723		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

LEAD: Grand mean= 0.45 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	0.05	-	-	0.05	0.19
	6	0.11	-	0.54	0.32	0.19
	11	0.12	-	0.53	0.32	0.19
	15	-	0.13	-	0.13	0.19
	2n	-	0.12	0.40	0.26	0.19
	6n	0.07	0.07	0.09	0.08	0.19
SHRUBS	1	0.05	0.08	-	0.07	0.24
	3	0.10	-	0.08	0.09	0.24
	4	0.17	0.13	0.80	0.37	0.24
	5	0.06	0.06	0.11	0.08	0.24
	13	0.31	-	0.28	0.30	0.24
	16	-	0.24	0.17	0.21	0.24
	20	-	-	0.10	0.10	0.24
	21	-	-	0.71	0.71	0.24
LICHENS	7	1.14	-	0.62	0.88	1.13
	8	0.76	1.01	1.00	0.92	1.13
	10	1.63	1.28	0.38	1.10	1.13
	12	1.42	-	-	1.42	1.13
	14	1.33	-	-	1.33	1.13
MOSSES	9	1.26	-	-	1.26	1.26
SOIL		7.21	4.11	18.56	9.96	9.96
REGION MEAN		0.54	0.40	0.51		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

MAGNES: Grand mean= 891.49 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	749.96	-	-	749.96	972.04
	6	935.27	-	786.94	861.11	972.04
	11	797.11	-	804.44	800.78	972.04
	15	-	1336.22	-	1336.22	972.04
	2n	-	887.01	885.92	886.47	972.04
	6n	904.01	1023.50	842.50	923.34	972.04
SHRUBS	1	1677.92	1491.54	-	1584.73	1260.12
	3	1083.95	-	1165.75	1124.85	1260.12
	4	1336.02	953.31	925.67	1071.67	1260.12
	5	1248.67	1405.23	1183.97	1279.29	1260.12
	13	1655.60	-	1689.67	1672.63	1260.12
	16	-	1559.24	1189.00	1374.12	1260.12
	20	-	-	1177.33	1177.33	1260.12
	21	-	-	796.33	796.33	1260.12
LICHENS	7	244.71	-	237.83	241.27	221.27
	8	238.00	210.85	252.42	233.76	221.27
	10	177.27	193.78	158.50	176.52	221.27
	12	168.27	-	-	168.27	221.27
	14	286.56	-	-	286.56	221.27
MOSSES	9	887.89	-	-	887.89	887.89
SOIL		836.04	50.56	1495.56	794.05	794.05
REGION MEAN		810.48	842.07	737.67		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

MANGAN: Grand mean= 641.698 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	610.309	-	-	610.309	360.514
	6	596.437	-	422.722	509.580	360.514
	11	93.949	-	190.700	142.324	360.514
	15	-	87.600	-	87.600	360.514
	2n	-	829.763	369.933	599.848	360.514
	6n	431.905	830.908	599.267	620.693	360.514
SHRUBS	1	1387.938	3382.002	-	2384.970	701.974
	3	589.054	-	652.500	620.777	701.974
	4	54.733	163.145	141.950	119.943	701.974
	5	1272.945	1927.585	1188.972	1463.167	701.974
	13	389.670	-	338.667	364.168	701.974
	16	-	40.497	39.440	39.969	701.974
	20	-	-	451.333	451.333	701.974
	21	-	-	171.467	171.467	701.974
LICHENS	7	62.400	-	82.783	72.592	56.083
	8	39.739	72.573	44.475	52.262	56.083
	10	28.839	50.162	50.500	43.167	56.083
	12	27.645	-	-	27.645	56.083
	14	84.747	-	-	84.747	56.083
MOSSES	9	251.113	-	-	251.113	251.113
SOIL		41.583	27.222	127.056	65.287	65.287
REGION MEAN		433.849	1009.304	349.227		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

MOLYB: Grand mean= 0.43 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	-	-	-	-	0.44
	6	-	-	0.29	0.29	0.44
	11	0.20	-	0.29	0.25	0.44
	15	-	0.64	-	0.64	0.44
	2n	-	0.65	0.47	0.56	0.44
	6n	0.37	0.38	0.24	0.33	0.44
SHRUBS	1	0.46	0.73	-	0.60	0.51
	3	0.35	-	0.26	0.31	0.51
	4	0.67	0.36	1.20	0.74	0.51
	5	0.51	0.52	0.44	0.49	0.51
	13	0.44	-	0.36	0.40	0.51
	16	-	0.46	0.32	0.39	0.51
	20	-	-	0.38	0.38	0.51
	21	-	-	0.76	0.76	0.51
LICHENS	7	0.33	-	0.12	0.23	0.34
	8	0.37	0.40	0.18	0.32	0.34
	10	0.41	0.37	0.12	0.30	0.34
	12	0.43	-	-	0.43	0.34
	14	0.40	-	-	0.40	0.34
MOSSES	9	-	-	-	-	-
SOIL		6.58	2.00	6.89	5.16	5.16
REGION MEAN		0.39	0.53	0.34		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

NICKEL: Grand mean= 0.947 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	1.745	-	-	1.745	0.910
	6	0.550	-	1.595	1.073	0.910
	11	1.074	-	1.330	1.202	0.910
	15	-	0.246	-	0.246	0.910
	2n	-	0.694	2.004	1.349	0.910
	6n	0.783	0.320	1.167	0.757	0.910
SHRUBS	1	1.606	0.932	-	1.269	1.225
	3	0.896	-	1.195	1.045	1.225
	4	2.379	0.909	2.929	2.073	1.225
	5	0.553	0.437	0.532	0.507	1.225
	13	1.521	-	1.475	1.498	1.225
	16	-	0.499	0.464	0.482	1.225
	20	-	-	1.881	1.881	1.225
	21	-	-	1.041	1.041	1.225
LICHENS	7	0.422	-	0.278	0.350	0.516
	8	0.476	0.755	0.440	0.557	0.516
	10	0.568	0.791	0.204	0.521	0.516
	12	0.588	-	-	0.588	0.516
	14	0.564	-	-	0.564	0.516
MOSSES	9	0.625	-	-	0.625	0.625
SOIL		11.821	5.311	16.389	11.174	11.174
REGION MEAN		0.822	0.699	1.032		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

PHOSPHOR: Grand mean= 834.1 ug/gm dry wt

		REGION				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	883.6	-	-	883.6	903.9
	6	1090.5	-	766.7	928.6	903.9
	11	759.3	-	786.8	773.0	903.9
	15	-	907.7	-	907.7	903.9
	2n	-	925.9	1055.3	990.6	903.9
	6n	1024.3	1039.9	914.7	993.0	903.9
SHRUBS	1	1096.8	1100.4	-	1098.6	1015.9
	3	1067.4	-	1085.3	1076.4	1015.9
	4	1305.5	1001.4	940.1	1082.3	1015.9
	5	957.1	892.4	866.0	905.2	1015.9
	13	915.4	-	874.8	895.1	1015.9
	16	-	1012.9	783.0	898.0	1015.9
	20	-	-	1365.3	1365.3	1015.9
	21	-	-	806.0	806.0	1015.9
LICHENS	7	481.1	-	539.5	510.3	416.0
	8	466.7	461.1	438.4	455.4	416.0
	10	330.7	356.5	354.5	347.2	416.0
	12	468.6	-	-	468.6	416.0
	14	298.3	-	-	298.3	416.0
MOSSES	9	967.8	-	-	967.8	967.8
SOIL		316.9	40.0	233.8	196.9	196.9
REGION MEAN		815.1	806.9	760.4		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

POTASS: Grand mean= 2144.6 ug/gm dry wt

		REGION				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	3123.4	-	-	3123.4	2500.5
	6	3841.6	-	1948.1	2894.9	2500.5
	11	1751.2	-	1192.7	1472.0	2500.5
	15	-	3778.4	-	3778.4	2500.5
	2n	-	1463.3	1350.7	1407.0	2500.5
	6n	3038.4	3162.4	1895.0	2698.6	2500.5
SHRUBS	1	2213.8	2166.3	-	2190.0	2775.4
	3	3360.3	-	2314.2	2837.2	2775.4
	4	2924.1	2700.0	2726.0	2783.4	2775.4
	5	2917.1	3279.1	2290.4	2828.9	2775.4
	13	2117.0	-	2545.3	2331.2	2775.4
	16	-	4377.3	2204.0	3290.6	2775.4
	20	-	-	3083.3	3083.3	2775.4
	21	-	-	2858.7	2858.7	2775.4
LICHENS	7	1327.2	-	1533.7	1430.5	1227.5
	8	1296.1	1105.7	1282.8	1228.2	1227.5
	10	731.8	1104.8	1055.0	963.9	1227.5
	12	1269.0	-	-	1269.0	1227.5
	14	1245.8	-	-	1245.8	1227.5
MOSSES	9	4069.2	-	-	4069.2	4069.2
SOIL		1132.1	54.9	641.1	609.4	609.4
REGION MEAN		2380.4	1944.1	1753.7		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

SILVER: Grand mean= 0.130 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	0.117	-	-	0.117	0.080
	6	0.076	-	0.136	0.106	0.080
	11	0.028	-	0.058	0.043	0.080
	15	-	0.025	-	0.025	0.080
	2n	-	0.137	0.085	0.111	0.080
	6n	0.106	0.151	0.176	0.144	0.080
SHRUBS	1	0.204	0.668	-	0.436	0.141
	3	0.110	-	0.143	0.127	0.141
	4	0.014	0.041	0.095	0.050	0.141
	5	0.235	0.365	0.264	0.288	0.141
	13	0.052	-	0.104	0.078	0.141
	16	-	0.027	0.015	0.021	0.141
	20	-	-	0.089	0.089	0.141
	21	-	-	0.042	0.042	0.141
LICHENS	7	0.006	-	0.031	0.018	0.013
	8	0.008	0.020	0.033	0.020	0.013
	10	0.007	0.006	0.027	0.013	0.013
	12	0.006	-	-	0.006	0.013
	14	0.007	-	-	0.007	0.013
MOSSES	9	0.020	-	-	0.020	0.020
SOIL		0.500	0.500	0.500	0.500	0.500
REGION MEAN		0.080	0.194	0.098		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

SODIUM: Grand mean= 23.1 ug/gm dry wt

		REGION				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	15.4	-	-	15.4	10.8
	6	10.3	-	8.3	9.3	10.8
	11	8.1	-	13.0	10.6	10.8
	15	-	6.7	-	6.7	10.8
	2n	-	14.3	5.7	10.0	10.8
	6n	13.6	16.9	14.9	15.1	10.8
SHRUBS	1	21.3	25.5	-	23.4	16.2
	3	19.7	-	21.5	20.6	16.2
	4	9.0	9.8	14.7	11.2	16.2
	5	15.1	15.9	11.7	14.2	16.2
	13	24.5	-	11.4	18.0	16.2
	16	-	17.1	22.6	19.9	16.2
	20	-	-	12.1	12.1	16.2
	21	-	-	10.1	10.1	16.2
LICHENS	7	35.5	-	28.4	31.9	54.8
	8	40.8	44.3	49.0	44.7	54.8
	10	40.2	49.0	19.5	36.2	54.8
	12	46.3	-	-	46.3	54.8
	14	114.9	-	-	114.9	54.8
MOSSES	9	69.2	-	-	69.2	69.2
SOIL		531.0	123.3	236.7	297.0	297.0
REGION MEAN		27.2	26.1	22.3		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

TITANIUM: Grand mean= 2.706 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	1.571	-	-	1.571	0.668
	6	0.398	-	0.569	0.483	0.668
	11	0.767	-	0.790	0.779	0.668
	15	-	0.286	-	0.286	0.668
	2n	-	1.328	0.895	1.112	0.668
	6n	0.345	0.321	0.253	0.306	0.668
SHRUBS	1	2.051	2.894	-	2.472	1.435
	3	1.637	-	1.063	1.350	1.435
	4	1.298	1.365	0.554	1.072	1.435
	5	1.045	1.266	0.772	1.028	1.435
	13	3.991	-	0.930	2.460	1.435
	16	-	1.658	2.030	1.844	1.435
	20	-	-	0.436	0.436	1.435
	21	-	-	0.821	0.821	1.435
LICHENS	7	6.519	-	2.641	4.580	6.853
	8	6.368	7.612	6.133	6.704	6.853
	10	8.492	7.884	2.682	6.352	6.853
	12	7.830	-	-	7.830	6.853
	14	8.797	-	-	8.797	6.853
MOSSES	9	4.889	-	-	4.889	4.889
SOIL		394.708	30.000	492.778	305.829	305.829
REGION MEAN		3.341	3.586	2.133		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

VANADIUM: Grand mean= 0.79 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	0.79	-	-	0.79	0.61
	6	0.59	-	0.48	0.53	0.61
	11	0.36	-	0.38	0.37	0.61
	15	-	0.84	-	0.84	0.61
	2n	-	0.79	0.48	0.63	0.61
	6n	0.59	0.64	0.46	0.57	0.61
SHRUBS	1	0.86	1.47	-	1.17	0.73
	3	0.66	-	0.60	0.63	0.73
	4	0.76	0.64	0.53	0.64	0.73
	5	0.72	0.89	0.66	0.76	0.73
	13	0.87	-	0.72	0.80	0.73
	16	-	0.95	0.64	0.79	0.73
	20	-	-	0.57	0.57	0.73
	21	-	-	0.51	0.51	0.73
LICHENS	7	0.88	-	0.53	0.71	0.96
	8	0.78	1.67	0.87	1.10	0.96
	10	1.02	1.86	0.44	1.11	0.96
	12	0.98	-	-	0.98	0.96
	14	0.90	-	-	0.90	0.96
MOSSES	9	1.29	-	-	1.29	1.29
SOIL		13.13	5.00	21.17	13.10	13.10
REGION MEAN		0.77	1.18	0.59		

SUMMARY TABLE OF WEIGHTED MEANS BY REGION AND SPECIES.
GRAND AND REGION MEANS EXCLUDE SOIL DATA.

ZINC: Grand mean= 32.642 ug/gm dry wt

		REGIONS				
		WOLLASTON LAKE	CLUFF LAKE	N. SASK.-/N.W.T.	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES					
TREES	2	62.997	-	-	62.997	76.384
	6	41.622	-	40.511	41.067	76.384
	11	97.618	-	131.500	114.559	76.384
	15	-	88.380	-	88.380	76.384
	2n	-	77.133	39.433	58.283	76.384
	6n	35.767	48.411	40.490	41.556	76.384
SHRUBS	1	24.013	27.765	-	25.889	27.812
	3	20.776	-	19.541	20.158	27.812
	4	21.291	14.326	35.219	23.612	27.812
	5	21.920	24.646	18.427	21.665	27.812
	13	13.648	-	13.163	13.405	27.812
	16	-	35.178	50.750	42.964	27.812
	20	-	-	57.833	57.833	27.812
	21	-	-	16.972	16.972	27.812
LICHENS	7	15.577	-	13.183	14.380	16.296
	8	12.208	14.093	11.475	12.592	16.296
	10	11.148	13.468	9.017	11.211	16.296
	12	20.374	-	-	20.374	16.296
	14	22.925	-	-	22.925	16.296
MOSSES	9	22.540	-	-	22.540	22.540
SOIL		9.125	3.344	28.500	13.656	13.656
REGION MEAN		28.358	36.574	37.729		

Appendix 8.4.2 Summary tables for stable elements, Wollaston Lake region. Elements in alphabetical order.

Species codes

1 Vaccinium myrtilloides
2 Pinus banksiana
3 Ledum groenlandicum
4 Alnus crispa
5 Vaccinium vitis-idaea
6 Picea mariana
7 Cladina rangiferina
8 Cladina mitis
9 Pleurozium schreberi
10 Cladina stellaris
11 Betula neoalaskana
12 Stereocaulon paschale
13 Empetrum nigrum
14 Cetraria nivalis
15 Populus tremuloides
16 Arctostaphyllos uva-ursi
20 Vaccinium uliginosum
21 Juniperus communis
29 Pinus banksiana (needles)
69 Picea mariana (needles)
22 Soil

Locality codes

Wollaston Bay region

1 Hidden Bay
2 Collins Creek
5 Hungry Island
6 Cunning Bay
7 Parks Lake
8 Labach Lake
9 Midwest Lake
10 Minor Bay

Cluff Lake region

11 Carswell Lake
12 South Gate
13 Carswell North
14 Jolley Lake
15 Sandy Lake
16 Mill Site

N. Sask./N.W.T.

17 Uranium City
18 Eagle Lake
19 Tazin River
20 Ena Lake
21 McInnes Lake
22 Dunvegan Lake

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

ALUMINUM: Grand mean= 195.87 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	383.46	-	-	-	-	-	-	-	383.46	157.25
	6	42.27	51.02	-	-	-	-	-	-	46.65	157.25
	11	-	-	38.35	33.92	33.45	-	-	-	35.24	157.25
	6n	-	-	56.62	62.60	49.70	52.97	62.94	46.32	55.19	157.25
SHRUBS	1	165.92	171.51	134.86	140.33	-	171.93	156.04	199.42	162.86	136.39
	3	61.12	68.93	-	85.13	136.55	143.10	109.88	123.39	104.01	136.39
	4	-	216.32	51.02	-	-	-	-	70.64	112.66	136.39
	5	112.35	136.65	124.43	141.20	138.09	209.24	241.54	155.56	157.38	136.39
	13	-	-	-	-	-	134.51	155.52	-	145.01	136.39
LICHENS	7	-	-	247.23	204.03	236.98	287.59	-	297.21	254.61	309.18
	8	263.18	271.41	276.73	-	-	-	-	430.32	310.41	309.18
	10	304.01	219.98	354.66	385.32	444.43	429.36	458.49	456.42	381.58	309.18
	12	-	-	-	279.34	276.68	304.31	306.03	-	291.59	309.18
	14	-	-	-	-	-	-	307.71	-	307.71	309.18
MOSSES	9	295.59	334.00	-	-	-	-	-	-	314.79	314.79
SOIL		4616.67	7400.00	6666.67	5133.33	7900.00	6033.33	5266.67	7500.00	6314.58	6314.58
LOCALITY MEAN		226.29	194.77	147.93	153.35	166.09	186.03	195.37	192.74		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

BARIUM: Grand mean= 10.418 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	10.052	-	-	-	-	-	-	-	10.052	10.787
	6	24.796	14.847	-	-	-	-	-	-	19.822	10.787
	11	-	-	6.317	1.446	9.045	-	-	-	5.602	10.787
	6n	-	-	11.891	22.782	12.862	20.496	16.150	9.828	15.668	10.787
SHRUBS	1	3.727	1.500	8.907	19.559	-	9.217	7.371	27.440	11.103	15.297
	3	21.512	5.580	-	9.288	13.816	23.610	17.957	18.027	15.684	15.297
	4	-	3.701	6.493	-	-	-	-	22.202	10.799	15.297
	5	5.534	7.061	15.133	19.419	6.709	18.057	15.078	6.044	11.629	15.297
	13	-	-	-	-	-	28.359	26.181	-	27.270	15.297
LICHENS	7	-	-	3.887	5.217	4.403	6.254	-	4.619	4.876	5.648
	8	4.357	4.027	5.433	-	-	-	-	5.243	4.765	5.648
	10	2.434	2.887	5.495	5.440	5.603	5.998	6.913	5.305	5.009	5.648
	12	-	-	-	4.904	4.308	4.389	5.355	-	4.739	5.648
	14	-	-	-	-	-	-	8.850	-	8.850	5.648
MOSSES	9	9.489	7.504	-	-	-	-	-	-	8.497	8.497
SOIL		16.667	65.500	163.333	63.000	27.667	30.667	28.333	57.667	56.604	56.604
LOCALITY MEAN		10.142	7.567	8.073	11.130	8.662	15.284	13.279	11.104		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

BERYLL: Grand mean= 0.032 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	0.023	-	-	-	-	-	-	-	0.023	0.014
	6	0.018	0.019	-	-	-	-	-	-	0.018	0.014
	11	-	-	0.009	0.007	0.006	-	-	-	0.008	0.014
	6n	-	-	0.011	0.011	0.011	0.012	0.012	0.011	0.011	0.014
SHRUBS	1	0.006	0.013	0.014	0.023	-	0.015	0.015	0.024	0.016	0.021
	3	0.020	0.023	-	0.013	0.016	0.017	0.012	0.013	0.016	0.021
	4	-	0.057	0.023	-	-	-	-	0.033	0.038	0.021
	5	0.013	0.006	0.014	0.015	0.013	0.015	0.015	0.013	0.013	0.021
	13	-	-	-	-	-	0.022	0.026	-	0.024	0.021
LICHENS	7	-	-	0.061	0.035	0.044	0.050	-	0.051	0.048	0.057
	8	0.029	0.032	0.042	-	-	-	-	0.091	0.049	0.057
	10	0.051	0.042	0.066	0.058	0.076	0.081	0.085	0.072	0.066	0.057
	12	-	-	-	0.062	0.047	0.074	0.065	-	0.062	0.057
	14	-	-	-	-	-	-	0.060	-	0.060	0.057
MOSSES	9	0.042	0.050	-	-	-	-	-	-	0.046	0.046
SOIL		1.150	2.033	2.433	2.167	2.667	1.967	1.800	2.933	2.144	2.144
LOCALITY MEAN		0.029	0.033	0.028	0.026	0.026	0.033	0.033	0.034		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

BORON: Grand mean= 5.04 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	9.28	-	-	-	-	-	-	-	9.28	6.06
	6	9.51	4.29	-	-	-	-	-	-	6.90	6.06
	11	-	-	4.62	3.10	5.33	-	-	-	4.35	6.06
	6n	-	-	2.72	1.72	2.07	7.35	3.26	5.57	3.78	6.06
SHRUBS	1	9.94	5.03	8.11	6.14	-	16.95	12.74	9.23	9.73	9.42
	3	15.18	9.50	-	7.77	8.42	13.39	11.21	10.86	10.90	9.42
	4	-	7.65	4.79	-	-	-	-	7.82	6.75	9.42
	5	8.17	7.01	5.98	5.88	6.51	8.36	10.27	6.26	7.31	9.42
	13	-	-	-	-	-	13.24	11.59	-	12.42	9.42
LICHENS	7	-	-	0.28	0.29	0.36	0.41	-	0.49	0.37	0.34
	8	0.50	0.29	0.17	-	-	-	-	0.21	0.29	0.34
	10	0.20	0.16	0.25	0.16	0.23	0.25	0.16	0.98	0.30	0.34
	12	-	-	-	0.55	0.53	0.71	0.51	-	0.58	0.34
	14	-	-	-	-	-	-	0.17	-	0.17	0.34
MOSSES	9	1.12	1.47	-	-	-	-	-	-	1.30	1.30
SOIL		6.33	38.50	83.67	82.33	5.00	38.67	100.00	5.00	44.94	44.94
LOCALITY MEAN		5.49	3.32	3.40	3.11	3.84	6.93	5.00	4.89		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

CADMIUM: Grand mean= 0.088 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	0.194	-	-	-	-	-	-	-	0.194	0.159
	6	0.027	0.019	-	-	-	-	-	-	0.023	0.159
	11	-	-	0.214	0.266	0.322	-	-	-	0.267	0.159
	6n	-	-	0.012	0.013	0.011	0.012	0.012	0.013	0.012	0.159
SHRUBS	1	0.056	0.022	0.046	0.020	-	0.029	0.028	0.034	0.034	0.030
	3	0.040	0.023	-	0.020	0.026	0.028	0.014	0.019	0.024	0.030
	4	-	0.010	0.049	-	-	-	-	0.028	0.029	0.030
	5	0.037	0.018	0.057	0.039	0.022	0.070	0.051	0.022	0.040	0.030
	13	-	-	-	-	-	0.025	0.025	-	0.025	0.030
LICHENS	7	-	-	0.126	0.127	0.138	0.127	-	0.121	0.128	0.149
	8	0.105	0.108	0.122	-	-	-	-	0.176	0.128	0.149
	10	0.136	0.096	0.197	0.124	0.142	0.120	0.157	0.110	0.135	0.149
	12	-	-	-	0.222	0.136	0.274	0.122	-	0.188	0.149
	14	-	-	-	-	-	-	0.165	-	0.165	0.149
MOSSES	9	0.243	0.156	-	-	-	-	-	-	0.200	0.200
SOIL		0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
LOCALITY MEAN		0.130	0.074	0.104	0.108	0.110	0.075	0.063	0.058		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

CALCIUM: Grand mean= 3657.87 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	3673.40	-	-	-	-	-	-	-	3673.40	3769.58
	6	4919.88	4533.48	-	-	-	-	-	-	4726.68	3769.58
	11	-	-	2459.04	3053.25	2614.29	-	-	-	2708.86	3769.58
	6n	-	-	5166.47	4884.36	4418.01	5529.21	5421.23	4539.21	4993.08	3769.58
SHRUBS	1	4777.90	4878.33	5640.60	5256.90	-	5507.17	6000.68	6791.13	5550.39	5705.47
	3	6026.60	6377.25	-	6186.09	6966.16	7116.49	6889.36	6618.93	6597.27	5705.47
	4	-	3567.20	2999.24	-	-	-	-	4490.94	3685.79	5705.47
	5	5162.81	6961.13	7590.87	6765.73	7359.33	7864.73	7572.53	7135.63	7051.60	5705.47
	13	-	-	-	-	-	5207.80	6076.77	-	5642.28	5705.47
LICHENS	7	-	-	661.36	549.25	453.06	675.89	-	560.69	580.05	660.73
	8	594.81	477.55	544.72	-	-	-	-	576.73	548.45	660.73
	10	352.07	230.50	413.04	392.30	365.89	424.65	407.51	433.10	377.38	660.73
	12	-	-	-	390.82	355.79	397.37	306.13	-	362.53	660.73
	14	-	-	-	-	-	-	1435.23	-	1435.23	660.73
MOSSES	9	2535.87	1911.47	-	-	-	-	-	-	2223.67	2223.67
SOIL		91.67	1015.00	1266.67	640.00	620.00	646.67	770.00	1000.00	756.25	756.25
LOCALITY MEAN		3157.10	3061.24	3254.23	3494.17	3690.16	4150.85	4257.45	3773.96		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

CHROMIUM: Grand mean= 0.394 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	0.726	-	-	-	-	-	-	-	0.726	0.378
	6	0.347	0.232	-	-	-	-	-	-	0.290	0.378
	11	-	-	0.169	0.142	0.161	-	-	-	0.157	0.378
	6n	-	-	0.247	0.339	0.174	0.234	0.199	0.227	0.237	0.378
SHRUBS	1	0.452	0.310	0.371	0.274	-	0.332	0.400	0.468	0.373	0.330
	3	0.375	0.225	-	0.274	0.266	0.362	0.270	0.319	0.299	0.330
	4	-	0.210	0.356	-	-	-	-	0.555	0.374	0.330
	5	0.304	0.246	0.253	0.290	0.325	0.362	0.393	0.319	0.311	0.330
	13	-	-	-	-	-	0.318	0.266	-	0.292	0.330
LICHENS	7	-	-	0.504	0.375	0.424	0.389	-	0.492	0.437	0.505
	8	0.418	0.399	0.406	-	-	-	-	0.518	0.435	0.505
	10	0.430	1.126	0.542	0.500	0.560	0.576	0.600	0.550	0.610	0.505
	12	-	-	-	0.520	0.533	0.714	0.533	-	0.575	0.505
	14	-	-	-	-	-	-	0.469	-	0.469	0.505
MOSSES	9	0.699	0.475	-	-	-	-	-	-	0.587	0.587
SOIL		127.667	195.983	333.333	343.333	163.333	226.667	250.000	233.333	234.206	234.206
LOCALITY MEAN		0.509	0.429	0.340	0.328	0.323	0.379	0.355	0.387		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

COBALT: Grand mean= 0.085 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	0.101	-	-	-	-	-	-	-	0.101	0.070
	6	0.024	0.019	-	-	-	-	-	-	0.022	0.070
	11	-	-	0.063	0.119	0.085	-	-	-	0.089	0.070
	6n	-	-	0.017	0.024	0.012	0.023	0.012	0.023	0.019	0.070
SHRUBS	1	0.029	0.048	0.053	0.055	-	0.031	0.027	0.094	0.048	0.124
	3	0.033	0.023	-	0.035	0.031	0.054	0.040	0.026	0.035	0.124
	4	-	0.746	0.325	-	-	-	-	0.252	0.441	0.124
	5	0.019	0.031	0.038	0.096	0.033	0.023	0.023	0.019	0.035	0.124
	13	-	-	-	-	-	0.052	0.066	-	0.059	0.124
LICHENS	7	-	-	0.128	0.076	0.098	0.103	-	0.115	0.104	0.110
	8	0.067	0.080	0.091	-	-	-	-	0.121	0.090	0.110
	10	0.079	0.069	0.110	0.101	0.128	0.130	0.126	0.124	0.108	0.110
	12	-	-	-	0.097	0.092	0.114	0.099	-	0.101	0.110
	14	-	-	-	-	-	-	0.149	-	0.149	0.110
MOSSES	9	0.117	0.112	-	-	-	-	-	-	0.115	0.115
SOIL		0.933	2.083	2.833	1.800	2.633	1.733	1.833	2.433	2.035	2.035
LOCALITY MEAN		0.070	0.104	0.096	0.075	0.062	0.060	0.059	0.080		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

COPPER: Grand mean= 2.701 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	2.094	-	-	-	-	-	-	-	2.094	2.407
	6	2.569	1.606	-	-	-	-	-	-	2.087	2.407
	11	-	-	3.497	3.835	3.717	-	-	-	3.683	2.407
	6n	-	-	1.313	1.484	1.109	1.088	1.196	1.193	1.230	2.407
SHRUBS	1	4.620	5.264	5.550	5.425	-	5.120	4.967	6.865	5.401	4.653
	3	5.284	4.094	-	4.046	3.775	3.807	3.264	3.272	3.934	4.653
	4	-	4.085	5.411	-	-	-	-	7.064	5.520	4.653
	5	4.699	3.756	4.563	4.549	3.579	4.101	3.687	3.525	4.057	4.653
	13	-	-	-	-	-	4.239	4.467	-	4.353	4.653
LICHENS	7	-	-	0.609	0.615	0.909	0.932	-	0.656	0.744	0.761
	8	0.680	0.563	0.626	-	-	-	-	0.678	0.637	0.761
	10	0.737	0.550	0.675	0.634	0.727	0.665	0.699	0.630	0.665	0.761
	12	-	-	-	1.112	1.123	1.126	1.369	-	1.182	0.761
	14	-	-	-	-	-	-	0.579	-	0.579	0.761
MOSSES	9	2.840	2.627	-	-	-	-	-	-	2.733	2.733
SOIL		1.717	4.967	37.000	6.200	3.867	2.667	3.233	7.167	8.352	8.352
LOCALITY MEAN		2.687	2.272	2.739	2.706	2.337	2.104	2.058	2.343		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

IRON: Grand mean= 109.372 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	56.972	-	-	-	-	-	-	-	56.972	36.606
	6	20.917	29.303	-	-	-	-	-	-	25.110	36.606
	11	-	-	29.328	25.075	29.736	-	-	-	28.046	36.606
	6n	-	-	21.171	29.980	20.606	27.329	20.323	28.766	24.696	36.606
SHRUBS	1	76.653	83.361	62.581	72.269	-	69.063	69.807	92.452	75.169	61.704
	3	49.569	36.317	-	40.813	52.771	61.517	48.077	52.559	48.803	61.704
	4	-	66.571	58.748	-	-	-	-	68.121	64.480	61.704
	5	25.323	40.875	32.927	39.464	21.604	44.926	43.521	34.155	35.349	61.704
	13	-	-	-	-	-	81.698	87.738	-	84.718	61.704
LICHENS	7	-	-	196.824	146.559	171.615	187.910	-	211.767	182.935	200.494
	8	139.546	164.563	169.531	-	-	-	-	271.891	186.383	200.494
	10	121.111	115.017	240.325	241.293	283.700	282.985	299.049	293.533	234.627	200.494
	12	-	-	-	222.774	202.093	273.843	226.730	-	231.360	200.494
	14	-	-	-	-	-	-	167.167	-	167.167	200.494
MOSSES	9	200.553	207.067	-	-	-	-	-	-	203.810	203.810
SOIL		3716.67	6466.67	6166.67	6033.33	7066.67	6200	5733.33	8133.33	6189.58	6189.58
LOCALITY MEAN		105.085	108.235	92.965	93.973	93.831	113.292	104.530	116.551		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

LEAD: Grand mean= 0.56 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	0.05	-	-	-	-	-	-	-	0.05	0.08
	6	0.08	0.13	-	-	-	-	-	-	0.11	0.08
	11	-	-	0.17	0.03	0.16	-	-	-	0.12	0.08
	6n	-	-	0.09	0.11	0.04	0.06	0.05	0.08	0.07	0.08
SHRUBS	1	0.03	0.03	0.05	0.09	-	0.06	0.06	0.06	0.05	0.14
	3	0.10	0.09	-	0.12	0.09	0.18	0.09	0.05	0.10	0.14
	4	-	0.04	0.03	-	-	-	-	0.43	0.17	0.14
	5	0.05	0.03	0.06	0.13	0.05	0.06	0.06	0.05	0.06	0.14
	13	-	-	-	-	-	0.27	0.35	-	0.31	0.14
LICHENS	7	-	-	0.79	0.87	1.69	1.39	-	0.98	1.14	1.26
	8	0.45	0.52	1.10	-	-	-	-	0.98	0.76	1.26
	10	1.33	0.96	2.01	1.47	2.53	1.59	1.77	1.36	1.63	1.26
	12	-	-	-	1.57	1.25	2.07	0.79	-	1.42	1.26
	14	-	-	-	-	-	-	1.33	-	1.33	1.26
MOSSES	9	1.45	1.06	-	-	-	-	-	-	1.26	1.26
SOIL		3.83	4.17	12.00	7.67	4.67	5.67	6.33	13.33	7.21	7.21
LOCALITY MEAN		0.62	0.50	0.49	0.49	0.67	0.63	0.49	0.45		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

MAGNES: Grand mean= 847.72 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	749.96	-	-	-	-	-	-	-	749.96	819.63
	6	911.75	958.79	-	-	-	-	-	-	935.27	819.63
	11	-	-	808.78	854.02	728.53	-	-	-	797.11	819.63
	6n	-	-	1062.93	1009.92	823.45	796.45	798.59	932.70	904.01	819.63
SHRUBS	1	1269.41	1822.37	1577.31	1722.46	-	1522.87	1739.54	2091.46	1677.92	1400.43
	3	1321.88	961.11	-	1248.58	956.69	1011.99	948.58	1138.79	1083.95	1400.43
	4	-	1777.12	853.39	-	-	-	-	1377.56	1336.02	1400.43
	5	1029.37	1205.50	1412.78	1436.77	1312.96	1228.79	1089.56	1273.61	1248.67	1400.43
	13	-	-	-	-	-	1678.05	1633.16	-	1655.60	1400.43
LICHENS	7	-	-	279.53	245.07	233.09	236.32	-	229.55	244.71	222.96
	8	271.00	233.60	219.65	-	-	-	-	227.77	238.00	222.96
	10	164.08	123.80	196.01	179.74	197.86	177.20	185.42	194.03	177.27	222.96
	12	-	-	-	161.68	179.82	171.06	160.51	-	168.27	222.96
	14	-	-	-	-	-	-	286.56	-	286.56	222.96
MOSSES	9	1070.77	705.02	-	-	-	-	-	-	887.89	887.89
SOIL		605.00	780.00	600.00	445.67	1466.67	900.00	683.33	1206.67	836.04	836.04
LOCALITY MEAN		831.51	821.01	816.25	865.58	704.80	783.91	787.37	873.39		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

MANGAN: Grand mean= 492.726 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	610.309	-	-	-	-	-	-	-	610.309	392.432
	6	937.342	255.533	-	-	-	-	-	-	596.437	392.432
	11	-	-	76.704	66.375	138.768	-	-	-	93.949	392.432
	6n	-	-	362.759	377.661	365.634	614.331	332.680	538.364	431.905	392.432
SHRUBS	1	3338.77	662.573	757.905	438.503	-	1773.44	1581.87	1162.5	1387.94	738.868
	3	557.377	275.265	-	626.246	405.491	833.341	511.192	914.465	589.054	738.868
	4	-	28.858	29.374	-	-	-	-	105.966	54.733	738.868
	5	996.204	1042.6	939.297	947.197	1000.76	1956.64	1593.16	1707.71	1272.94	738.868
	13	-	-	-	-	-	440.610	338.730	-	389.670	738.868
LICHENS	7	-	-	43.514	61.388	47.575	85.952	-	73.573	62.400	48.674
	8	61.097	26.981	23.476	-	-	-	-	47.404	39.739	48.674
	10	46.836	17.019	26.066	23.483	26.100	30.486	24.320	36.404	28.839	48.674
	12	-	-	-	25.024	24.473	38.933	22.149	-	27.645	48.674
	14	-	-	-	-	-	-	84.747	-	84.747	48.674
MOSSES	9	356.103	146.123	-	-	-	-	-	-	251.113	251.113
SOIL		25.500	21.500	41.667	48.000	63.000	41.000	40.000	52.000	41.583	41.583
LOCALITY MEAN		703.669	231.495	275.425	309.766	329.347	639.044	460.886	521.161		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

MOLYB: Grand mean= 0.41 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	-	-	-	-	-	-	-	-	-	0.29
	6	-	-	-	-	-	-	-	-	-	0.29
	11	-	-	0.15	0.25	0.21	-	-	-	0.20	0.29
	6n	-	-	0.42	0.50	0.29	0.36	0.34	0.33	0.37	0.29
SHRUBS	1	-	-	0.41	0.30	-	0.47	0.54	0.58	0.46	0.49
	3	-	-	-	0.34	0.32	0.41	0.31	0.40	0.35	0.49
	4	-	-	0.73	-	-	-	-	0.61	0.67	0.49
	5	-	-	0.43	0.46	0.42	0.63	0.64	0.48	0.51	0.49
	13	-	-	-	-	-	0.47	0.40	-	0.44	0.49
LICHENS	7	-	-	0.38	0.28	0.32	0.31	-	0.36	0.33	0.39
	8	-	-	0.27	-	-	-	-	0.47	0.37	0.39
	10	-	-	0.39	0.34	0.45	0.40	0.50	0.40	0.41	0.39
	12	-	-	-	0.41	0.36	0.50	0.47	-	0.43	0.39
	14	-	-	-	-	-	-	0.40	-	0.40	0.39
MOSSES	9	-	-	-	-	-	-	-	-	-	-
SOIL		4.33	7.33	8.33	6.00	7.33	6.67	5.33	7.33	6.58	6.58
LOCALITY MEAN		-	-	0.39	0.36	0.33	0.42	0.42	0.42		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

NICKEL: Grand mean= 0.883 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	1.745	-	-	-	-	-	-	-	1.745	1.181
	6	0.522	0.578	-	-	-	-	-	-	0.550	1.181
	11	-	-	0.914	1.106	1.202	-	-	-	1.074	1.181
	6n	-	-	0.544	1.613	0.704	0.573	0.745	0.520	0.783	1.181
SHRUBS	1	0.998	1.573	1.018	2.352	-	1.144	1.748	2.407	1.606	1.391
	3	1.132	1.176	-	0.601	1.013	0.814	0.971	0.568	0.896	1.391
	4	-	2.939	1.701	-	-	-	-	2.498	2.379	1.391
	5	0.464	0.463	0.513	0.660	0.927	0.512	0.586	0.300	0.553	1.391
	13	-	-	-	-	-	1.065	1.978	-	1.521	1.391
LICHENS	7	-	-	0.539	0.358	0.420	0.393	-	0.401	0.422	0.524
	8	0.496	0.578	0.378	-	-	-	-	0.452	0.476	0.524
	10	0.384	0.843	0.468	0.744	0.509	0.664	0.503	0.430	0.568	0.524
	12	-	-	-	0.487	0.630	0.614	0.622	-	0.588	0.524
	14	-	-	-	-	-	-	0.564	-	0.564	0.524
MOSSES	9	0.675	0.576	-	-	-	-	-	-	0.625	0.625
SOIL		7.567	9.000	40.667	11.067	5.633	6.500	6.233	7.900	11.821	11.821
LOCALITY MEAN		0.778	0.850	0.756	1.031	0.814	0.671	0.876	0.797		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

PHOSPHOR: Grand mean= 810.6 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	883.6	-	-	-	-	-	-	-	883.6	894.6
	6	1282.4	898.7	-	-	-	-	-	-	1090.5	894.6
	11	-	-	700.5	890.9	686.4	-	-	-	759.3	894.6
	6n	-	-	852.4	1299.1	1015.2	1007.7	1078.2	893.3	1024.3	894.6
SHRUBS	1	1045.0	1088.4	910.3	1115.5	-	1050.8	1173.6	1293.8	1096.8	1068.4
	3	827.6	1160.2	-	1333.3	1082.2	1051.5	977.4	1039.7	1067.4	1068.4
	4	-	1946.5	579.7	-	-	-	-	1390.2	1305.5	1068.4
	5	996.2	941.0	950.5	1116.4	948.2	955.1	928.9	820.7	957.1	1068.4
	13	-	-	-	-	-	898.0	932.8	-	915.4	1068.4
LICHENS	7	-	-	494.9	472.0	455.3	519.3	-	464.2	481.1	409.1
	8	607.1	449.4	390.9	-	-	-	-	419.2	466.7	409.1
	10	368.6	206.4	338.7	349.8	313.0	307.2	392.9	368.9	330.7	409.1
	12	-	-	-	463.4	505.8	471.1	434.3	-	468.6	409.1
	14	-	-	-	-	-	-	298.3	-	298.3	409.1
MOSSES	9	1237.9	697.7	-	-	-	-	-	-	967.8	967.8
SOIL		86.7	341.7	636.7	313.3	256.7	183.3	146.7	570.0	316.9	316.9
LOCALITY MEAN		941.3	802.1	666.1	903.9	763.6	809.7	818.9	815.6		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

POTASS: Grand mean= 2250.6 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	3123.4	-	-	-	-	-	-	-	3123.4	2704.6
	6	3553.6	4129.7	-	-	-	-	-	-	3841.6	2704.6
	11	-	-	1579.2	2212.5	1462.0	-	-	-	1751.2	2704.6
	6n	-	-	3039.0	3083.6	2871.1	2963.1	3165.1	3108.6	3038.4	2704.6
SHRUBS	1	963.9	2096.4	2533.5	1948.3	-	2792.0	3373.6	1788.5	2213.8	2706.5
	3	4313.1	5118.8	-	2881.9	3192.2	3156.8	2821.3	2038.1	3360.3	2706.5
	4	-	2920.2	1638.8	-	-	-	-	4213.4	2924.1	2706.5
	5	3441.0	2293.7	3111.6	3070.3	3057.1	3074.2	2398.0	2891.3	2917.1	2706.5
	13	-	-	-	-	-	2148.5	2085.6	-	2117.0	2706.5
LICHENS	7	-	-	1583.6	1464.0	1217.5	1154.0	-	1217.2	1327.2	1174.0
	8	1685.0	1422.1	1071.6	-	-	-	-	1005.9	1296.1	1174.0
	10	527.3	530.9	762.7	865.9	708.0	591.5	1062.2	806.1	731.8	1174.0
	12	-	-	-	1072.4	1425.7	1275.5	1302.5	-	1269.0	1174.0
	14	-	-	-	-	-	-	1245.8	-	1245.8	1174.0
MOSSES	9	4177.9	3960.5	-	-	-	-	-	-	4069.2	4069.2
SOIL		826.7	800.0	1043.3	1233.3	1233.3	1533.3	1120.0	1266.7	1132.1	1132.1
LOCALITY MEAN		2882.1	3043.5	1958.8	2138.5	2136.1	2254.3	2346.1	2283.7		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

SILVER: Grand mean= 0.086 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	0.117	-	-	-	-	-	-	-	0.117	0.081
	6	0.116	0.036	-	-	-	-	-	-	0.076	0.081
	11	-	-	0.028	0.013	0.042	-	-	-	0.028	0.081
	6n	-	-	0.064	0.059	0.081	0.207	0.048	0.179	0.106	0.081
SHRUBS	1	0.499	0.056	0.104	0.054	-	0.279	0.224	0.211	0.204	0.123
	3	0.083	0.038	-	0.141	0.079	0.174	0.086	0.172	0.110	0.123
	4	-	0.008	0.008	-	-	-	-	0.025	0.014	0.123
	5	0.157	0.142	0.170	0.214	0.132	0.396	0.338	0.329	0.235	0.123
	13	-	-	-	-	-	0.050	0.055	-	0.052	0.123
LICHENS	7	-	-	0.005	0.005	0.005	0.006	-	0.006	0.006	0.007
	8	0.011	0.008	0.005	-	-	-	-	0.007	0.008	0.007
	10	0.004	<0.002	0.006	0.006	0.020	0.006	0.006	0.007	0.007	0.007
	12	-	-	-	0.006	0.006	0.006	0.006	-	0.006	0.007
	14	-	-	-	-	-	-	0.007	-	0.007	0.007
MOSSES	9	0.019	0.021	-	-	-	-	-	-	0.020	0.020
SOIL		0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
LOCALITY MEAN		0.097	0.031	0.048	0.059	0.059	0.146	0.077	0.123		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

SODIUM: Grand mean= 27.4 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	15.4	-	-	-	-	-	-	-	15.4	12.1
	6	10.2	10.5	-	-	-	-	-	-	10.3	12.1
	11	-	-	9.7	7.7	7.1	-	-	-	8.1	12.1
	6n	-	-	19.9	12.8	11.7	13.8	16.0	7.5	13.6	12.1
SHRUBS	1	25.0	20.2	20.7	22.6	-	19.6	17.0	23.9	21.3	17.9
	3	18.2	14.1	-	19.5	17.9	21.6	26.6	20.2	19.7	17.9
	4	-	12.8	4.8	-	-	-	-	9.3	9.0	17.9
	5	15.8	21.5	11.2	13.4	15.9	14.3	12.1	16.9	15.1	17.9
	13	-	-	-	-	-	21.1	27.9	-	24.5	17.9
LICHENS	7	-	-	39.8	38.1	27.0	31.4	-	41.1	35.5	55.5
	8	40.1	32.7	36.1	-	-	-	-	54.2	40.8	55.5
	10	28.8	29.3	45.8	44.6	39.5	52.9	33.6	46.7	40.2	55.5
	12	-	-	-	57.0	47.7	38.1	42.3	-	46.3	55.5
	14	-	-	-	-	-	-	114.9	-	114.9	55.5
MOSSES	9	67.7	70.6	-	-	-	-	-	-	69.2	69.2
SOIL		186.7	328.3	680.0	926.7	376.7	696.7	680.0	373.3	531.0	531.0
LOCALITY MEAN		33.7	32.3	22.5	25.1	21.5	24.6	33.5	24.1		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

TITANIUM: Grand mean= 3.630 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	1.571	-	-	-	-	-	-	-	1.571	0.899
	6	0.181	0.615	-	-	-	-	-	-	0.398	0.899
	11	-	-	1.128	0.443	0.731	-	-	-	0.767	0.899
	6n	-	-	0.378	0.361	0.278	0.391	0.263	0.401	0.345	0.899
SHRUBS	1	1.342	1.004	2.563	2.411	-	2.121	1.853	3.060	2.051	2.004
	3	1.549	0.754	-	0.748	1.860	2.443	1.832	2.274	1.637	2.004
	4	-	0.760	1.268	-	-	-	-	1.867	1.298	2.004
	5	0.047	0.822	0.969	1.344	0.639	1.633	1.331	1.574	1.045	2.004
	13	-	-	-	-	-	3.753	4.230	-	3.991	2.004
LICHENS	7	-	-	7.297	5.615	5.985	6.419	-	7.278	6.519	7.601
	8	4.975	5.214	6.092	-	-	-	-	9.191	6.368	7.601
	10	6.230	6.448	8.324	8.009	9.398	9.449	10.318	9.760	8.492	7.601
	12	-	-	-	8.137	6.840	8.494	7.849	-	7.830	7.601
	14	-	-	-	-	-	-	8.797	-	8.797	7.601
MOSSES	9	4.746	5.032	-	-	-	-	-	-	4.889	4.889
SOIL		117.667	466.667	443.333	260.000	693.333	306.667	446.667	423.333	394.708	394.708
LOCALITY MEAN		3.051	3.078	3.197	3.052	3.054	3.666	3.854	3.779		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

VANADIUM: Grand mean= 0.79 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES								SPECIES MEAN	GROUP MEAN
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY		
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	0.79	-	-	-	-	-	-	-	0.79	0.58
	6	0.65	0.52	-	-	-	-	-	-	0.59	0.58
	11	-	-	0.32	0.37	0.38	-	-	-	0.36	0.58
	6n	-	-	0.67	0.80	0.45	0.56	0.52	0.55	0.59	0.58
SHRUBS	1	1.06	0.87	0.68	0.61	-	0.87	0.97	0.99	0.86	0.78
	3	0.75	0.48	-	0.64	0.60	0.78	0.61	0.72	0.66	0.78
	4	-	0.57	0.76	-	-	-	-	0.96	0.76	0.78
	5	0.60	0.67	0.71	0.70	0.64	0.91	0.84	0.70	0.72	0.78
	13	-	-	-	-	-	0.90	0.85	-	0.87	0.78
LICHENS	7	-	-	0.98	0.74	0.83	0.90	-	0.94	0.88	0.91
	8	0.64	0.65	0.75	-	-	-	-	1.07	0.78	0.91
	10	0.77	0.62	1.05	0.96	1.20	1.14	1.25	1.13	1.02	0.91
	12	-	-	-	0.96	0.85	1.15	0.98	-	0.98	0.91
	14	-	-	-	-	-	-	0.90	-	0.90	0.91
MOSSES	9	1.48	1.10	-	-	-	-	-	-	1.29	1.29
SOIL		7.00	14.00	13.00	12.00	20.33	11.00	13.33	14.33	13.13	13.13
LOCALITY MEAN		0.93	0.73	0.71	0.71	0.67	0.83	0.79	0.81		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

ZINC: Grand mean= 25.383 ug/gm dry wt

		WOLLASTON LAKE LOCALITIES									
		HIDDEN BAY	COLLINS CREEK	HUNGRY ISLAND	CUNNING BAY	RABBIT LAKE	LABACH LAKE	MIDWEST LAKE	MINOR BAY	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES										
TREES	2	62.997	-	-	-	-	-	-	-	62.997	65.949
	6	51.625	31.619	-	-	-	-	-	-	41.622	65.949
	11	-	-	129.720	82.600	80.535	-	-	-	97.618	65.949
	6n	-	-	37.213	42.010	28.241	39.942	37.499	29.696	35.767	65.949
SHRUBS	1	26.774	16.136	27.029	17.190	-	25.123	28.612	27.228	24.013	20.330
	3	17.292	14.884	-	27.128	19.028	24.700	21.896	20.506	20.776	20.330
	4	-	10.181	34.012	-	-	-	-	19.679	21.291	20.330
	5	22.791	15.215	23.942	26.530	19.351	24.426	22.994	20.114	21.920	20.330
	13	-	-	-	-	-	13.521	13.774	-	13.648	20.330
LICHENS	7	-	-	19.070	16.434	14.157	14.754	-	13.469	15.577	16.446
	8	14.211	11.587	11.281	-	-	-	-	11.751	12.208	16.446
	10	12.729	8.426	13.095	9.135	11.358	10.227	13.982	10.230	11.148	16.446
	12	-	-	-	18.047	12.414	22.798	28.237	-	20.374	16.446
	14	-	-	-	-	-	-	22.925	-	22.925	16.446
MOSSES	9	28.063	17.017	-	-	-	-	-	-	22.540	22.540
SOIL		4.350	7.317	22.333	8.533	8.000	6.800	4.833	10.833	9.125	9.125
LOCALITY MEAN		30.282	18.187	42.092	33.486	28.740	25.937	27.011	21.132		

Appendix 8.4.3 Summary tables for stable elements, Cluff Lake region. Elements in alphabetical order.

Species codes

1 Vaccinium myrtilloides
2 Pinus banksiana
3 Ledum groenlandicum
4 Alnus crispa
5 Vaccinium vitis-idaea
6 Picea mariana
7 Cladina rangiferina
8 Cladina mitis
9 Pleurozium schreberi
10 Cladina stellaris
11 Betula neoalaskana
12 Stereocaulon paschale
13 Empetrum nigrum
14 Cetraria nivalis
15 Populus tremuloides
16 Arctostaphyllos uva-ursi
20 Vaccinium uliginosum
21 Juniperus communis
29 Pinus banksiana (needles)
69 Picea mariana (needles)
22 Soil

Locality codes

Wollaston Bay region

1 Hidden Bay
2 Collins Creek
5 Hungry Island
6 Cunning Bay
7 Parks Lake
8 Labach Lake
9 Midwest Lake
10 Minor Bay

Cluff Lake region

11 Carswell Lake
12 South Gate
13 Carswell North
14 Jolley Lake
15 Sandy Lake
16 Mill Site

N. Sask./N.W.T.

17 Uranium City
18 Eagle Lake
19 Tazin River
20 Ena Lake
21 McInnes Lake
22 Dunvegan Lake

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

ALUMINUM: Grand mean= 254.72 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	42.52	-	-	-	-	-	42.52	200.66
	2n	570.09	556.46	429.74	341.86	503.65	606.85	501.44	200.66
	6n	65.30	-	46.43	62.34	-	-	58.02	200.66
SHRUBS	1	163.65	183.02	174.05	225.84	158.00	287.92	198.75	145.44
	4	39.08	50.44	-	-	-	74.38	54.63	145.44
	5	165.29	197.47	215.01	179.40	189.26	299.44	207.64	145.44
	16	-	-	-	-	-	120.73	120.73	145.44
LICHENS	8	331.43	368.76	283.12	356.83	282.52	496.98	353.27	345.50
	10	-	-	-	-	337.73	-	337.73	345.50
SOIL		506.67	830.00	600.00	400.00	590.00	853.33	630.00	630.00
LOCALITY MEAN		226.69	356.29	238.58	253.85	329.13	433.15		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

ALUMINUM: Grand mean= 404.43 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	602.99	714.83	473.34	733.55	582.35	621.41	621.41
SHRUBS	1	174.00	165.24	175.57	143.66	278.76	187.44	187.44
SOIL		513.33	846.67	723.33	706.67	533.33	664.67	664.67
LOCALITY MEAN		388.49	440.03	324.45	438.60	430.55		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

BARIUM: Grand mean= 11.483 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	24.835	-	-	-	-	-	24.835	15.323
	2n	7.102	8.566	6.308	3.345	7.452	10.547	7.220	15.323
	6n	11.625	-	20.485	9.631	-	-	13.913	15.323
SHRUBS	1	20.329	15.540	21.495	14.470	19.742	11.377	17.159	18.495
	4	22.929	17.142	-	-	-	12.253	17.441	18.495
	5	17.508	4.422	12.334	6.147	11.349	1.261	8.837	18.495
	16	-	-	-	-	-	30.544	30.544	18.495
LICHENS	8	6.660	4.330	4.073	3.816	3.142	4.461	4.414	4.069
	10	-	-	-	-	3.723	-	3.723	4.068
SOIL		8.267	8.833	7.833	9.800	11.233	16.000	10.328	10.328
LOCALITY MEAN		13.812	8.421	11.461	6.871	8.810	9.622		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

BARIUM: Grand mean= 11.222 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	5.063	6.192	2.136	7.142	12.009	6.508	6.508
SHRUBS	1	8.347	19.843	20.966	16.475	14.051	15.936	15.936
SOIL		15.333	28.000	14.167	19.000	8.000	16.900	16.900
LOCALITY MEAN		6.705	13.018	11.551	11.809	13.030		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

BERYLL: Grand mean= 0.025 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	0.017	-	-	-	-	-	0.017	0.016
	2n	0.017	0.015	0.015	0.012	0.017	0.024	0.016	0.016
	6n	0.012	-	0.016	0.015	-	-	0.014	0.016
SHRUBS	1	0.016	0.015	0.017	0.017	0.016	0.019	0.017	0.019
	4	0.020	0.019	-	-	-	0.016	0.018	0.019
	5	0.017	0.015	0.016	0.014	0.015	0.020	0.016	0.019
	16	-	-	-	-	-	0.026	0.026	0.019
LICHENS	8	0.054	0.060	0.046	0.053	0.050	0.062	0.054	0.056
	10	-	-	-	-	0.057	-	0.057	0.056
SOIL		0.633	0.800	0.733	0.667	0.567	0.667	0.678	0.678
LOCALITY MEAN		0.029	0.030	0.026	0.027	0.029	0.035		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

BERYLL: Grand mean= 0.016 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	0.012	0.015	0.012	0.017	0.024	0.016	0.016
SHRUBS	1	0.015	0.017	0.015	0.015	0.018	0.016	0.016
SOIL		0.733	0.700	0.733	0.667	0.533	0.673	0.673
LOCALITY MEAN		0.013	0.016	0.013	0.016	0.021		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

BORON: Grand mean= 12.10 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	11.08	-	-	-	-	-	11.08	11.20
	2n	10.79	9.50	9.59	11.90	8.40	9.37	9.92	11.20
	6n	13.12	-	14.63	10.01	-	-	12.59	11.20
SHRUBS	1	24.61	32.40	35.35	23.37	37.04	31.44	30.70	14.48
	4	11.75	9.05	-	-	-	5.01	8.60	14.48
	5	13.60	9.80	11.22	10.67	17.98	8.67	11.99	14.48
	16	-	-	-	-	-	6.65	6.65	14.48
LICHENS	8	0.39	0.32	0.33	0.41	0.26	0.33	0.34	0.30
	10	-	-	-	-	0.26	-	0.26	0.30
SOIL		103.33	97.33	5.00	12.00	6.67	5.67	38.33	38.33
LOCALITY MEAN		9.57	8.97	11.91	9.46	12.06	7.54		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

BORON: Grand mean= 18.47 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	8.76	17.76	7.23	9.13	7.53	10.08	10.08
SHRUBS	1	23.94	36.67	26.76	20.25	26.71	26.87	26.87
SOIL		5.67	11.67	113.33	69.33	11.33	42.27	42.27
LOCALITY MEAN		16.35	27.21	16.99	14.69	17.12		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

CADMIUM: Grand mean= 0.070 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	0.269	-	-	-	-	-	0.269	0.144
	2n	0.149	0.101	0.148	0.193	0.146	0.148	0.147	0.144
	6n	0.014	-	0.016	0.016	-	-	0.015	0.144
SHRUBS	1	0.055	0.044	0.040	0.042	0.041	0.035	0.043	0.029
	4	0.019	0.030	-	-	-	0.011	0.020	0.029
	5	0.053	0.027	0.044	0.025	0.037	0.035	0.037	0.029
	16	-	-	-	-	-	0.016	0.016	0.029
LICHENS	8	0.059	0.078	0.076	0.069	0.162	0.046	0.082	0.076
	10	-	-	-	-	0.071	-	0.071	0.076
SOIL		0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
LOCALITY MEAN		0.082	0.071	0.067	0.069	0.100	0.073		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

CADMIUM: Grand mean= 0.073 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	0.066	0.131	0.152	0.116	0.076	0.108	0.108
SHRUBS	1	0.053	0.022	0.024	0.059	0.032	0.038	0.038
SOIL		0.500	0.500	0.500	0.500	0.500	0.500	0.500
LOCALITY MEAN		0.059	0.076	0.088	0.088	0.054		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

CALCIUM: Grand mean= 5724.58 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	10040.27	-	-	-	-	-	10040.27	7544.85
	2n	5893.07	5875.13	5366.50	5759.13	5050.27	6374.53	5719.77	7544.85
	6n	5666.65	-	7546.40	7410.49	-	-	6874.51	7544.85
SHRUBS	1	6755.67	5893.47	6389.83	6583.43	6103.92	6573.35	6383.28	7986.29
	4	10587.24	7971.06	-	-	-	6228.20	8262.17	7986.29
	5	8116.00	7949.23	8162.47	7145.40	7137.17	9456.00	7994.38	7986.29
	16	-	-	-	-	-	9305.32	9305.32	7986.29
LICHENS	8	512.99	724.46	530.56	503.02	464.79	493.08	538.15	440.07
	10	-	-	-	-	341.98	-	341.98	440.07
SOIL		86.00	82.33	79.33	105.67	142.00	180.00	112.56	112.56
LOCALITY MEAN		5399.76	4623.61	4754.39	4650.75	4024.73	4919.44		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

CALCIUM: Grand mean= 5233.23 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	3448.37	4662.73	2505.93	2548.73	5294.27	3692.01	3692.01
SHRUBS	1	6901.23	8401.80	6189.87	5622.29	6757.09	6774.46	6774.46
SOIL		203.33	510.00	316.67	330.00	71.67	286.33	286.33
LOCALITY MEAN		5174.80	6532.27	4347.90	4085.51	6025.68		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

CHROMIUM: Grand mean= 0.430 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	0.322	-	-	-	-	-	0.322	0.320
	2n	0.429	0.401	0.348	0.334	0.437	0.535	0.414	0.320
	6n	0.192	-	0.265	0.216	-	-	0.224	0.320
SHRUBS	1	0.614	0.764	0.621	0.679	0.446	0.650	0.629	0.390
	4	0.257	0.306	-	-	-	0.195	0.252	0.390
	5	0.359	0.354	0.446	0.328	0.373	0.473	0.389	0.390
	16	-	-	-	-	-	0.290	0.290	0.390
LICHENS	8	0.655	0.536	0.422	0.473	0.440	0.581	0.518	0.480
	10	-	-	-	-	0.443	-	0.443	0.480
SOIL		203.333	260.000	253.333	233.333	160.000	203.333	218.889	218.889
LOCALITY MEAN		0.459	0.470	0.421	0.417	0.429	0.506		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

CHROMIUM: Grand mean= 0.414 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	0.310	0.364	0.362	0.373	0.458	0.374	0.374
SHRUBS	1	0.463	0.334	0.319	0.450	0.707	0.455	0.455
SOIL		256.667	283.333	260.000	250.000	160.000	242.000	242.000
LOCALITY MEAN		0.387	0.349	0.341	0.411	0.583		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

COBALT: Grand mean= 0.063 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
GROUP	SPECIES	CARSWELL LAKE ug/gm dry wt	SOUTH GATE ug/gm dry wt	CARSWELL NORTH ug/gm dry wt	JOLLEY LAKE ug/gm dry wt	SANDY LAKE ug/gm dry wt	MILL SITE ug/gm dry wt	SPECIES MEAN	GROUP MEAN
TREES	15	0.164	-	-	-	-	-	0.164	0.081
	2n	0.061	0.052	0.043	0.024	0.105	0.079	0.061	0.081
	6n	0.012	-	0.024	0.015	-	-	0.017	0.081
SHRUBS	1	0.055	0.057	0.036	0.033	0.037	0.045	0.044	0.061
	4	0.158	0.112	-	-	-	0.093	0.121	0.061
	5	0.025	0.018	0.022	0.015	0.018	0.020	0.020	0.061
	16	-	-	-	-	-	0.060	0.060	0.061
LICHENS	8	0.097	0.099	0.086	0.101	0.093	0.108	0.098	0.100
	10	-	-	-	-	0.103	-	0.103	0.100
SOIL		0.733	0.600	0.700	0.633	0.533	0.600	0.633	0.633
LOCALITY MEAN		0.085	0.071	0.049	0.048	0.077	0.081		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

COBALT: Grand mean= 0.043 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
GROUP	SPECIES	SOUTH GATE ug/gm dry wt	CARSWELL NORTH ug/gm dry wt	JOLLEY LAKE ug/gm dry wt	SANDY LAKE ug/gm dry wt	MILL SITE ug/gm dry wt	SPECIES MEAN	GROUP MEAN
TREES	2n	0.051	0.020	0.035	0.056	0.073	0.047	0.047
SHRUBS	1	0.046	0.037	0.037	0.032	0.047	0.040	0.040
SOIL		1.000	0.667	0.600	0.600	0.533	0.680	0.680
LOCALITY MEAN		0.049	0.029	0.036	0.044	0.060		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

COPPER: Grand mean= 2.659 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	3.839	-	-	-	-	-	3.839	2.206
	2n	1.464	1.416	1.172	1.376	1.511	1.491	1.405	2.206
	6n	1.155	-	1.423	1.541	-	-	1.373	2.206
SHRUBS	1	5.159	5.671	5.187	5.374	4.504	4.568	5.077	3.782
	4	4.569	4.103	-	-	-	3.935	4.203	3.782
	5	3.320	3.234	4.155	3.928	3.698	3.585	3.653	3.782
	16	-	-	-	-	-	2.195	2.195	3.782
LICHENS	8	0.480	0.599	0.526	0.532	0.728	0.703	0.595	0.597
	10	-	-	-	-	0.599	-	0.599	0.597
SOIL		2.333	2.500	2.433	2.833	2.400	11.000	3.917	3.917
LOCALITY MEAN		2.327	2.117	2.165	2.214	2.092	1.922		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

COPPER: Grand mean= 3.046 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	1.739	1.583	2.388	2.183	1.199	1.818	1.818
SHRUBS	1	4.064	4.875	4.063	3.487	4.882	4.274	4.274
SOIL		3.000	3.800	3.100	4.267	1.667	3.167	3.167
LOCALITY MEAN		2.902	3.229	3.225	2.835	3.040		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

IRON: Grand mean= 90.700 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	18.378	-	-	-	-	-	18.378	33.852
	2n	51.922	47.494	39.853	51.930	58.853	90.677	56.788	33.852
	6n	29.981	-	26.565	22.623	-	-	26.390	33.852
SHRUBS	1	80.952	95.819	97.484	102.447	72.332	123.201	95.373	60.107
	4	45.334	55.749	-	-	-	48.325	49.803	60.107
	5	41.006	36.239	45.848	37.119	41.893	63.040	44.191	60.107
	16	-	-	-	-	-	51.063	51.063	60.107
LICHENS	8	208.340	213.573	182.837	220.049	178.593	296.593	216.664	216.824
	10	-	-	-	-	216.984	-	216.984	216.824
SOIL		1766.667	2166.667	2366.667	1933.333	1666.667	2066.667	1994.444	1994.444
LOCALITY MEAN		99.177	107.890	95.904	109.036	104.585	152.892		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

IRON: Grand mean= 58.212 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	37.081	40.625	36.033	34.810	72.751	44.260	44.260
SHRUBS	1	66.619	58.606	59.901	52.984	122.708	72.164	72.164
SOIL		2200.000	2566.667	2366.667	2266.667	1433.333	2166.667	2166.667
LOCALITY MEAN		51.850	49.616	47.967	43.897	97.730		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

LEAD: Grand mean= 0.30 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	0.13	-	-	-	-	-	0.13	0.11
	2n	0.20	0.07	0.08	0.05	0.11	0.22	0.12	0.11
	6n	0.08	-	0.06	0.06	-	-	0.07	0.11
SHRUBS	1	0.07	0.06	0.07	0.07	0.07	0.17	0.08	0.13
	4	0.16	0.14	-	-	-	0.07	0.13	0.13
	5	0.07	0.06	0.06	0.06	0.06	0.08	0.06	0.13
	16	-	-	-	-	-	0.24	0.24	0.13
LICHENS	8	0.65	0.56	0.71	0.97	1.32	1.88	1.01	1.15
	10	-	-	-	-	1.28	-	1.28	1.15
SOIL		3.33	5.00	3.33	2.00	3.67	7.33	4.11	4.11
LOCALITY MEAN		0.29	0.24	0.28	0.36	0.49	0.75		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

LEAD: Grand mean= 0.12 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	0.13	0.26	0.28	0.09	0.11	0.17	0.17
SHRUBS	1	0.06	0.07	0.07	0.06	0.07	0.07	0.07
SOIL		6.33	6.33	3.67	5.33	2.00	4.73	4.73
LOCALITY MEAN		0.09	0.16	0.18	0.08	0.09		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

MAGNES: Grand mean= 999.62 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	1336.22	-	-	-	-	-	1336.22	1082.25
	2n	844.34	948.33	875.45	978.80	785.62	889.55	887.01	1082.25
	6n	996.60	-	977.23	1096.68	-	-	1023.50	1082.25
SHRUBS	1	1334.40	1331.95	1562.87	1456.22	1451.66	1812.12	1491.54	1352.33
	4	1118.40	680.53	-	-	-	1060.99	953.31	1352.33
	5	1241.51	1244.70	1432.19	1571.67	1365.30	1576.00	1405.23	1352.33
	16	-	-	-	-	-	1559.24	1559.24	1352.33
LICHENS	8	210.43	213.57	230.90	203.53	180.93	225.72	210.85	202.31
	10	-	-	-	-	193.78	-	193.78	202.31
SOIL		47.33	46.33	40.00	34.00	59.67	76.00	50.56	50.56
LOCALITY MEAN		833.64	749.21	884.92	918.41	793.82	872.45		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

MAGNES: Grand mean= 1096.54 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	834.12	1085.81	930.95	755.64	821.09	885.52	885.52
SHRUBS	1	1291.27	1445.27	1344.53	1023.85	1432.87	1307.56	1307.56
SOIL		52.33	92.00	71.67	75.33	50.33	68.33	68.33
LOCALITY MEAN		1062.69	1265.54	1137.74	889.75	1126.98		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

MANGAN: Grand mean= 1225.21 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	87.600	-	-	-	-	-	87.600	582.757
	2n	715.010	820.783	549.263	817.530	1168.790	907.200	829.763	582.757
	6n	643.900	-	884.735	964.089	-	-	830.908	582.757
SHRUBS	1	3599.733	2680.107	3079.110	3200.825	3646.820	4085.416	3382.002	1378.307
	4	213.289	177.989	-	-	-	98.157	163.145	1378.307
	5	2272.170	1222.247	2177.427	1393.957	1820.510	2679.200	1927.585	1378.307
	16	-	-	-	-	-	40.497	40.497	1378.307
LICHENS	8	55.419	54.922	75.086	88.447	106.910	54.654	72.573	61.367
	10	-	-	-	-	50.162	-	50.162	61.367
SOIL		37.667	14.333	13.667	32.333	25.333	40.000	27.222	27.222
LOCALITY MEAN		855.329	745.273	1140.118	1092.216	1326.997	895.891		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

MANGAN: Grand mean= 1504.84 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	500.313	286.537	320.667	598.177	607.667	462.672	462.672
SHRUBS	1	3063.100	2043.947	1302.500	3046.356	3279.152	2547.011	2547.011
SOIL		49.667	57.667	40.000	53.000	12.667	42.600	42.600
LOCALITY MEAN		1781.707	1165.242	811.583	1822.266	1943.409		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

MOLYB: Grand mean= 0.53 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	0.64	-	-	-	-	-	0.64	0.55
	2n	0.70	0.61	0.53	0.52	0.72	0.81	0.65	0.55
	6n	0.30	-	0.47	0.36	-	-	0.38	0.55
SHRUBS	1	0.74	0.78	0.67	0.85	0.62	0.70	0.73	0.52
	4	0.37	0.40	-	-	-	0.32	0.36	0.52
	5	0.49	0.39	0.64	0.40	0.55	0.67	0.52	0.52
	16	-	-	-	-	-	0.46	0.46	0.52
LICHENS	8	0.36	0.38	0.32	0.40	0.38	0.54	0.40	0.38
	10	-	-	-	-	0.37	-	0.37	0.38
SOIL		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
LOCALITY MEAN		0.48	0.51	0.49	0.49	0.56	0.63		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

MOLYB: Grand mean= 0.59 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	0.63	0.70	0.57	0.72	0.60	0.64	0.64
SHRUBS	1	0.61	0.43	0.45	0.56	0.67	0.54	0.54
SOIL		2.00	2.00	2.00	2.33	2.00	2.07	2.07
LOCALITY MEAN		0.62	0.57	0.51	0.64	0.63		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

NICKEL: Grand mean= 0.670 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	0.246	-	-	-	-	-	0.246	0.420
	2n	0.498	0.696	0.585	0.565	1.230	0.589	0.694	0.420
	6n	0.233	-	0.354	0.372	-	-	0.320	0.420
SHRUBS	1	1.010	1.228	0.839	1.024	0.813	0.679	0.932	0.694
	4	0.817	0.990	-	-	-	0.921	0.909	0.694
	5	0.251	0.622	0.551	0.413	0.388	0.394	0.437	0.694
	16	-	-	-	-	-	0.499	0.499	0.694
LICHENS	8	0.807	0.874	0.601	0.711	0.782	0.753	0.755	0.773
	10	-	-	-	-	0.791	-	0.791	0.773
SOIL		4.900	5.500	6.200	5.233	4.333	5.700	5.311	5.311
LOCALITY MEAN		0.608	0.839	0.588	0.633	0.872	0.655		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

NICKEL: Grand mean= 0.736 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	0.839	0.308	0.348	0.783	0.833	0.622	0.622
SHRUBS	1	1.240	0.865	0.666	0.692	0.786	0.850	0.850
SOIL		6.133	8.600	6.233	6.233	3.833	6.207	6.207
LOCALITY MEAN		1.039	0.586	0.507	0.737	0.810		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

PHOSPHOR: Grand mean= 869.1 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	907.7	-	-	-	-	-	907.7	957.9
	2n	931.9	989.5	875.8	904.2	938.9	915.4	925.9	957.9
	6n	868.8	-	1108.5	1142.3	-	-	1039.9	957.9
SHRUBS	1	1104.4	959.9	1134.6	1213.8	1054.9	1134.9	1100.4	1001.8
	4	1067.6	917.5	-	-	-	1018.9	1001.4	1001.8
	5	855.7	828.6	1004.7	994.0	923.0	748.6	892.4	1001.8
	16	-	-	-	-	-	1012.9	1012.9	1001.8
LICHENS	8	406.8	465.0	508.3	471.0	469.6	445.7	461.1	408.8
	10	-	-	-	-	356.5	-	356.5	408.8
SOIL		36.7	30.0	40.0	36.7	50.0	46.7	40.0	40.0
LOCALITY MEAN		773.0	785.5	856.7	866.1	780.3	780.0		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

PHOSPHOR: Grand mean= 1182.6 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	1109.4	1305.0	1387.5	1445.0	881.1	1225.6	1225.6
SHRUBS	1	1158.2	1255.0	1108.2	1096.2	1080.4	1139.6	1139.6
SOIL		50.0	93.3	70.0	80.0	40.0	66.7	66.7
LOCALITY MEAN		1133.8	1280.0	1247.8	1270.6	980.7		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

POTASS: Grand mean= 2270.7 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	3778.4	-	-	-	-	-	3778.4	2801.4
	2n	1126.4	1573.8	1751.0	1651.1	717.6	1960.1	1463.3	2801.4
	6n	2452.2	-	3664.8	3370.0	-	-	3162.4	2801.4
SHRUBS	1	2475.2	2317.9	1938.4	1433.9	1716.5	3116.2	2166.3	3130.7
	4	2633.4	2735.5	-	-	-	2731.0	2700.0	3130.7
	5	3317.1	3850.6	3193.7	3202.4	2880.0	3230.8	3279.1	3130.7
	16	-	-	-	-	-	4377.3	4377.3	3130.7
LICHENS	8	959.7	1099.9	1147.4	1168.3	876.7	1382.4	1105.7	1105.3
	10	-	-	-	-	1104.8	-	1104.8	1105.3
SOIL		40.0	66.0	43.3	33.3	50.0	96.7	54.9	54.9
LOCALITY MEAN		2073.5	1880.6	2140.4	1999.0	1335.5	2235.4		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

POTASS: Grand mean= 2278.3 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	1910.8	2010.2	1747.2	1561.1	2109.9	1867.8	1867.8
SHRUBS	1	3247.4	2644.0	1918.8	2556.9	3076.4	2688.7	2688.7
SOIL		60.0	93.3	102.3	33.3	40.0	65.8	65.8
LOCALITY MEAN		2579.1	2327.1	1833.0	2059.0	2593.1		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

SILVER: Grand mean= 0.236 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	0.025	-	-	-	-	-	0.025	0.104
	2n	0.112	0.141	0.076	0.125	0.217	0.147	0.137	0.104
	6n	0.113	-	0.196	0.143	-	-	0.151	0.104
SHRUBS	1	0.679	0.817	0.644	0.663	0.623	0.584	0.668	0.275
	4	0.048	0.042	-	-	-	0.031	0.041	0.275
	5	0.483	0.267	0.373	0.340	0.295	0.433	0.365	0.275
	16	-	-	-	-	-	0.027	0.027	0.275
LICHENS	8	0.006	0.006	0.006	0.006	0.005	0.092	0.020	0.013
	10	-	-	-	-	0.006	-	0.006	0.013
SOIL		0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
LOCALITY MEAN		0.164	0.174	0.217	0.214	0.227	0.170		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

SILVER: Grand mean= 0.243 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	0.082	0.062	0.086	0.129	0.094	0.090	0.090
SHRUBS	1	0.570	0.289	0.159	0.490	0.468	0.395	0.395
SOIL		0.500	0.500	0.500	0.900	0.500	0.580	0.580
LOCALITY MEAN		0.326	0.176	0.122	0.310	0.281		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

SODIUM: Grand mean= 22.8 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	6.7	-	-	-	-	-	6.7	12.6
	2n	10.1	13.2	13.5	22.5	13.7	12.9	14.3	12.6
	6n	20.9	-	12.8	17.0	-	-	16.9	12.6
SHRUBS	1	24.9	31.1	22.7	25.2	19.8	29.3	25.5	17.1
	4	14.1	6.1	-	-	-	9.4	9.8	17.1
	5	14.1	15.4	16.9	13.1	14.5	21.3	15.9	17.1
	16	-	-	-	-	-	17.1	17.1	17.1
LICHENS	8	55.6	46.8	43.3	41.7	32.5	45.8	44.3	46.7
	10	-	-	-	-	49.0	-	49.0	46.7
SOIL		216.7	226.7	80.0	80.0	53.3	83.3	123.3	123.3
LOCALITY MEAN		28.6	25.9	25.4	26.9	23.9	26.0		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

SODIUM: Grand mean= 17.1 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	13.2	17.5	7.0	7.4	17.0	12.4	12.4
SHRUBS	1	24.5	17.1	17.9	20.7	28.6	21.8	21.8
SOIL		72.7	83.3	243.3	163.3	94.7	131.5	131.5
LOCALITY MEAN		18.8	17.3	12.5	14.0	22.8		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

TITANIUM: Grand mean= 2.833 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	0.286	-	-	-	-	-	0.286	0.645
	2n	1.325	1.168	0.867	1.408	1.482	1.718	1.328	0.645
	6n	0.293	-	0.364	0.307	-	-	0.321	0.645
SHRUBS	1	2.286	4.246	2.329	3.188	2.149	3.164	2.894	1.796
	4	1.254	1.276	-	-	-	1.566	1.365	1.796
	5	1.530	1.415	1.554	1.348	1.708	0.039	1.266	1.796
	16	-	-	-	-	-	1.658	1.658	1.796
LICHENS	8	7.476	8.007	7.055	7.774	6.562	8.797	7.612	7.748
	10	-	-	-	-	7.884	-	7.884	7.748
SOIL		26.667	38.000	36.667	20.000	20.667	38.000	30.000	30.000
LOCALITY MEAN		3.267	3.829	3.204	3.633	3.545	4.041		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

TITANIUM: Grand mean= 1.476 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	0.803	0.723	0.550	0.358	1.620	0.811	0.811
SHRUBS	1	2.102	1.651	2.268	1.342	3.348	2.142	2.142
SOIL		13.667	30.667	25.667	21.333	31.667	24.600	24.600
LOCALITY MEAN		1.453	1.187	1.409	0.850	2.484		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

VANADIUM: Grand mean= 1.10 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
		CARSWELL LAKE	SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	15	0.84	-	-	-	-	-	0.84	0.76
	2n	0.77	0.82	0.60	0.77	0.88	0.90	0.79	0.76
	6n	0.49	-	0.80	0.65	-	-	0.64	0.76
SHRUBS	1	1.39	1.55	1.39	1.74	1.26	1.47	1.47	0.98
	4	0.60	0.76	-	-	-	0.55	0.64	0.98
	5	0.83	0.71	1.01	0.67	1.05	1.06	0.89	0.98
	16	-	-	-	-	-	0.95	0.95	0.98
LICHENS	8	1.43	1.73	1.42	1.75	1.74	1.92	1.67	1.76
	10	-	-	-	-	1.86	-	1.86	1.76
SOIL		5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
LOCALITY MEAN		1.02	1.19	1.11	1.22	1.28	1.27		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

VANADIUM: Grand mean= 0.79 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
		SOUTH GATE	CARSWELL NORTH	JOLLEY LAKE	SANDY LAKE	MILL SITE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES							
TREES	2n	0.51	0.57	0.56	0.43	0.67	0.55	0.55
SHRUBS	1	1.14	0.83	0.88	1.02	1.34	1.04	1.04
SOIL		5.00	5.00	5.00	5.00	5.00	5.00	5.00
LOCALITY MEAN		0.82	0.70	0.72	0.72	1.00		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

ZINC: Grand mean= 35.971 ug/gm dry wt

		CLUFF LAKE LOCALITIES							
GROUP	SPECIES	CARSWELL LAKE ug/gm dry wt	SOUTH GATE ug/gm dry wt	CARSWELL NORTH ug/gm dry wt	JOLLEY LAKE ug/gm dry wt	SANDY LAKE ug/gm dry wt	MILL SITE ug/gm dry wt	SPECIES MEAN	GROUP MEAN
TREES	15	88.380	-	-	-	-	-	88.380	71.308
	2n	90.366	68.868	59.114	78.920	94.670	70.857	77.133	71.308
	6n	42.602	-	50.708	51.923	-	-	48.411	71.308
SHRUBS	1	28.615	23.990	30.309	31.792	26.294	25.590	27.765	25.479
	4	7.750	18.855	-	-	-	16.372	14.326	25.479
	5	20.841	19.021	27.810	22.100	23.827	34.278	24.646	25.479
	16	-	-	-	-	-	35.178	35.178	25.479
LICHENS	8	11.744	12.799	14.134	15.145	20.142	10.592	14.093	13.780
	10	-	-	-	-	13.468	-	13.468	13.780
SOIL		1.033	1.033	1.767	2.433	2.733	11.067	3.344	3.344
LOCALITY MEAN		34.865	34.096	32.702	35.838	45.512	36.434		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

ZINC: Grand mean= 50.749 ug/gm dry wt

		CLUFF LAKE FIRE LOCALITIES						
GROUP	SPECIES	SOUTH GATE ug/gm dry wt	CARSWELL NORTH ug/gm dry wt	JOLLEY LAKE ug/gm dry wt	SANDY LAKE ug/gm dry wt	MILL SITE ug/gm dry wt	SPECIES MEAN	GROUP MEAN
TREES	2n	64.685	84.629	81.744	58.709	44.499	66.853	66.853
SHRUBS	1	40.484	36.686	34.551	33.036	28.462	34.644	34.644
SOIL		4.600	7.567	5.433	7.900	0.767	5.253	5.253
LOCALITY MEAN		52.585	60.658	58.148	45.873	36.481		

Appendix 8.4.4 Summary tables for stable elements, Northernmost Sask./N.W.T. Region. Elements in alphabetical order.

Species codes

1 Vaccinium myrtilloides
2 Pinus banksiana
3 Ledum groenlandicum
4 Alnus crispa
5 Vaccinium vitis-idaea
6 Picea mariana
7 Cladina rangiferina
8 Cladina mitis
9 Pleurozium schreberi
10 Cladina stellaris
11 Betula neoalaskana
12 Stereocaulon paschale
13 Empetrum nigrum
14 Cetraria nivalis
15 Populus tremuloides
16 Arctostaphyllos uva-ursi
20 Vaccinium uliginosum
21 Juniperus communis
29 Pinus banksiana (needles)
69 Picea mariana (needles)
22 Soil

Locality codes

Wollaston Bay region

1 Hidden Bay
2 Collins Creek
5 Hungry Island
6 Cunning Bay
7 Parks Lake
8 Labach Lake
9 Midwest Lake
10 Minor Bay

Cluff Lake region

11 Carswell Lake
12 South Gate
13 Carswell North
14 Jolley Lake
15 Sandy Lake
16 Mill Site

N. Sask./N.W.T.

17 Uranium City
18 Eagle Lake
19 Tazin River
20 Ena Lake
21 McInnes Lake
22 Dunvegan Lake

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

ALUMINUM: Grand mean= 108.59 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	69.70	56.35	-	-	25.33	-	50.46	168.93
	11	23.77	38.27	24.70	28.97	12.32	29.77	26.30	168.93
	2n	538.00	461.67	311.33	446.67	-	-	439.42	168.93
	6n	38.40	64.60	29.60	39.37	-	33.70	41.13	168.93
SHRUBS	3	95.70	59.13	75.87	56.67	40.14	55.07	63.76	66.61
	4	42.67	41.67	20.45	29.33	-	-	33.53	66.61
	5	134.40	106.50	111.80	102.43	98.80	110.30	110.71	66.61
	13	-	-	-	-	31.67	72.57	52.12	66.61
	16	94.25	-	-	-	-	-	94.25	66.61
	20	-	-	-	-	-	78.47	78.47	66.61
	21	33.45	-	-	-	-	-	33.45	66.61
LICHENS	7	-	-	-	-	82.00	122.00	102.00	144.58
	8	300.33	271.67	205.00	167.33	-	-	236.08	144.58
	10	-	-	-	-	69.00	122.33	95.67	144.58
SOIL		13666.67	14333.33	3066.67	6766.67	6966.67	4300.00	8183.33	8183.33
LOCALITY MEAN		195.81	175.70	132.08	133.94	50.40	77.67		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

BARIUM: Grand mean= 18.136 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	12.405	15.515	-	-	13.943	-	13.954	20.382
	11	19.060	49.800	43.967	20.617	36.067	33.933	33.907	20.382
	2n	8.590	6.250	7.040	8.973	-	-	7.713	20.382
	6n	36.000	5.700	28.933	26.847	-	14.922	22.480	20.382
SHRUBS	3	17.980	14.897	12.108	15.253	15.837	13.317	14.899	24.161
	4	43.603	27.800	35.233	34.147	-	-	35.196	24.161
	5	9.843	3.377	12.150	7.437	10.227	7.957	8.498	24.161
	13	-	-	-	-	15.692	45.300	30.496	24.161
	16	15.660	-	-	-	-	-	15.660	24.161
	20	-	-	-	-	-	8.477	8.477	24.161
	21	55.900	-	-	-	-	-	55.900	24.161
LICHENS	7	-	-	-	-	3.767	6.180	4.973	4.879
	8	7.903	5.220	6.433	5.120	-	-	6.169	4.879
	10	-	-	-	-	3.043	3.947	3.495	4.879
SOIL		88.667	76.333	26.667	21.667	40.000	24.333	46.278	46.278
LOCALITY MEAN		17.491	14.447	17.637	14.293	14.109	16.085		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

BERYLL: Grand mean= 0.014 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	0.010	0.011	-	-	0.010	-	0.010	0.010
	11	0.010	0.015	0.007	0.008	0.008	0.006	0.009	0.010
	2n	0.010	0.011	0.012	0.010	-	-	0.011	0.010
	6n	0.012	0.010	0.011	0.012	-	0.011	0.011	0.010
SHRUBS	3	0.015	0.013	0.013	0.012	0.011	0.012	0.013	0.016
	4	0.023	0.021	0.020	0.020	-	-	0.021	0.016
	5	0.013	0.012	0.014	0.014	0.013	0.012	0.013	0.016
	13	-	-	-	-	0.013	0.015	0.014	0.016
	16	0.020	-	-	-	-	-	0.020	0.016
	20	-	-	-	-	-	0.012	0.012	0.016
	21	0.018	-	-	-	-	-	0.018	0.016
LICHENS	7	-	-	-	-	0.007	0.010	0.008	0.017
	8	0.045	0.055	0.020	0.017	-	-	0.034	0.017
	10	-	-	-	-	0.005	0.012	0.008	0.017
SOIL		3.000	3.667	1.200	1.333	1.667	1.300	2.028	2.028
LOCALITY MEAN		0.024	0.027	0.015	0.014	0.009	0.011		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

BORON: Grand mean= 6.90 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	4.26	7.02	-	-	5.47	-	5.58	6.59
	11	10.16	15.93	8.04	8.76	8.25	7.94	9.84	6.59
	2n	5.13	9.12	2.23	3.18	-	-	4.91	6.59
	6n	3.12	2.09	4.25	3.69	-	7.39	4.11	6.59
SHRUBS	3	16.53	14.02	11.52	10.17	14.56	11.40	13.03	9.47
	4	7.88	8.90	7.42	5.00	-	-	7.30	9.47
	5	11.77	6.93	9.24	6.73	7.37	8.32	8.39	9.47
	13	-	-	-	-	9.17	10.69	9.93	9.47
	16	7.11	-	-	-	-	-	7.11	9.47
	20	-	-	-	-	-	9.83	9.83	9.47
	21	10.72	-	-	-	-	-	10.72	9.47
LICHENS	7	-	-	-	-	0.52	0.56	0.54	0.36
	8	0.33	0.54	0.20	0.22	-	-	0.32	0.36
	10	-	-	-	-	0.24	0.23	0.23	0.36
SOIL		5.00	5.00	6.33	5.00	5.00	5.00	5.22	5.22
LOCALITY MEAN		5.84	6.88	4.81	4.24	5.87	6.04		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

CADMIUM: Grand mean= 0.103 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	0.010	0.016	-	-	0.010	-	0.012	0.160
	11	0.670	0.261	0.166	0.376	0.556	0.198	0.371	0.160
	2n	0.082	0.099	0.092	0.107	-	-	0.095	0.160
	6n	0.012	0.010	0.011	0.025	-	0.011	0.014	0.160
SHRUBS	3	0.015	0.013	0.013	0.025	0.014	0.012	0.015	0.204
	4	0.023	0.021	0.025	0.042	-	-	0.028	0.204
	5	0.022	0.017	0.014	0.017	0.022	0.017	0.018	0.204
	13	-	-	-	-	0.013	0.015	0.014	0.204
	16	0.015	-	-	-	-	-	0.015	0.204
	20	-	-	-	-	-	1.310	1.310	0.204
	21	0.030	-	-	-	-	-	0.030	0.204
LICHENS	7	-	-	-	-	0.051	0.050	0.050	0.052
	8	0.040	0.052	0.079	0.095	-	-	0.066	0.052
	10	-	-	-	-	0.039	0.038	0.038	0.052
SOIL		0.533	0.600	0.633	2.100	0.533	0.567	0.828	0.828
LOCALITY MEAN		0.105	0.065	0.062	0.097	0.115	0.162		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

CALCIUM: Grand mean= 4091.91 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	3485.00	4500.00	-	-	3746.67	-	3910.56	4023.68
	11	3602.00	3140.00	2773.33	3708.33	4416.67	2443.33	3347.28	4023.68
	2n	3503.33	3561.67	3900.00	3896.67	-	-	3715.42	4023.68
	6n	7200.00	4560.00	6360.00	6206.67	-	4493.33	5764.00	4023.68
SHRUBS	3	6090.00	5686.67	5385.00	5593.33	4373.33	4876.67	5334.17	5621.51
	4	4356.00	4966.67	6133.33	5223.33	-	-	5169.83	5621.51
	5	4956.67	4683.33	5823.33	6143.33	4940.00	4686.67	5205.56	5621.51
	13	-	-	-	-	5800.00	3928.67	4864.33	5621.51
	16	6090.00	-	-	-	-	-	6090.00	5621.51
	20	-	-	-	-	-	3713.33	3713.33	5621.51
	21	8973.33	-	-	-	-	-	8973.33	5621.51
LICHENS	7	-	-	-	-	621.33	562.00	591.67	528.17
	8	714.00	496.67	660.67	590.67	-	-	615.50	528.17
	10	-	-	-	-	388.33	366.33	377.33	528.17
SOIL		1533.33	1010.00	920.00	1146.67	2000.00	1223.33	1305.56	1305.56
LOCALITY MEAN		3583.37	3116.48	3595.22	3615.96	3208.09	2744.61		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

CHROMIUM: Grand mean= 0.156 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	0.194	0.192	-	-	0.069	-	0.152	0.138
	11	0.118	0.120	0.074	0.126	0.070	0.067	0.096	0.138
	2n	0.207	0.257	0.133	0.204	-	-	0.200	0.138
	6n	0.072	0.057	0.103	0.130	-	0.105	0.093	0.138
SHRUBS	3	0.174	0.163	0.103	0.105	0.090	0.084	0.120	0.149
	4	0.187	0.151	0.147	0.150	-	-	0.159	0.149
	5	0.237	0.132	0.140	0.156	0.147	0.185	0.166	0.149
	13	-	-	-	-	0.119	0.171	0.145	0.149
	16	0.087	-	-	-	-	-	0.087	0.149
	20	-	-	-	-	-	0.115	0.115	0.149
	21	0.248	-	-	-	-	-	0.248	0.149
LICHENS	7	-	-	-	-	0.129	0.184	0.157	0.215
	8	0.348	0.421	0.280	0.278	-	-	0.332	0.215
	10	-	-	-	-	0.132	0.183	0.157	0.215
SOIL		98.000	71.333	115.000	100.667	93.667	102.667	96.889	96.889
LOCALITY MEAN		0.231	0.248	0.171	0.190	0.106	0.136		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

COBALT: Grand mean= 0.143 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	0.092	0.250	-	-	0.013	-	0.118	0.195
	11	0.201	0.696	0.094	0.278	0.280	0.118	0.278	0.195
	2n	0.090	0.661	0.063	0.161	-	-	0.244	0.195
	6n	0.036	0.190	0.021	0.035	-	0.014	0.059	0.195
SHRUBS	3	0.058	0.069	0.042	0.064	0.018	0.015	0.044	0.118
	4	0.276	1.344	0.163	0.264	-	-	0.512	0.118
	5	0.043	0.186	0.036	0.031	0.018	0.026	0.056	0.118
	13	-	-	-	-	0.045	0.040	0.043	0.118
	16	0.028	-	-	-	-	-	0.028	0.118
	20	-	-	-	-	-	0.058	0.058	0.118
	21	0.083	-	-	-	-	-	0.083	0.118
LICHENS	7	-	-	-	-	0.024	0.046	0.035	0.057
	8	0.085	0.166	0.069	0.067	-	-	0.097	0.057
	10	-	-	-	-	0.032	0.045	0.039	0.057
SOIL		5.000	30.000	1.667	2.667	3.000	3.000	7.556	7.556
LOCALITY MEAN		0.101	0.409	0.069	0.115	0.067	0.049		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

COPPER: Grand mean= 3.246 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	2.090	1.964	-	-	1.483	-	1.846	2.902
	11	4.503	5.807	4.083	4.650	4.533	4.383	4.660	2.902
	2n	2.001	2.154	1.552	2.000	-	-	1.927	2.902
	6n	2.136	1.786	2.723	1.896	-	2.601	2.228	2.902
SHRUBS	3	4.930	3.587	5.038	4.363	3.543	3.243	4.118	4.311
	4	5.351	10.970	5.133	8.127	-	-	7.395	4.311
	5	4.500	3.340	3.727	3.690	3.033	3.767	3.676	4.311
	13	-	-	-	-	4.242	3.617	3.929	4.311
	16	2.770	-	-	-	-	-	2.770	4.311
	20	-	-	-	-	-	5.987	5.987	4.311
	21	2.302	-	-	-	-	-	2.302	4.311
LICHENS	7	-	-	-	-	0.890	0.917	0.903	0.622
	8	0.473	0.674	0.634	0.671	-	-	0.613	0.622
	10	-	-	-	-	0.408	0.292	0.350	0.622
SOIL		5.000	50.667	3.000	3.667	4.667	2.667	11.611	11.611
LOCALITY MEAN		2.438	3.309	2.684	2.971	2.421	2.750		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

IRON: Grand mean= 45.861 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	26.350	30.400	-	-	12.516	-	23.089	29.239
	11	30.500	34.667	26.400	29.167	21.567	28.467	28.461	29.239
	2n	35.233	44.533	31.933	32.717	-	-	36.104	29.239
	6n	28.800	13.300	27.607	23.960	-	22.960	23.325	29.239
SHRUBS	3	66.700	37.200	32.117	28.333	22.643	26.033	35.504	35.055
	4	44.707	44.767	36.867	32.400	-	-	39.685	35.055
	5	51.400	26.767	27.573	26.573	18.720	23.917	29.158	35.055
	13	-	-	-	-	19.700	38.600	29.150	35.055
	16	52.200	-	-	-	-	-	52.200	35.055
	20	-	-	-	-	-	27.147	27.147	35.055
	21	32.543	-	-	-	-	-	32.543	35.055
LICHENS	7	-	-	-	-	46.167	91.267	68.717	100.528
	8	220.000	196.000	135.667	117.000	-	-	167.167	100.528
	10	-	-	-	-	49.067	82.333	65.700	100.528
SOIL		13133.3	9333.333	5200.000	7833.333	6800.000	7066.667	8227.778	8227.778
LOCALITY MEAN		100.159	88.959	65.500	58.239	28.337	47.146		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

LEAD: Grand mean= 0.40 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	0.20	1.04	-	-	0.37	-	0.54	0.39
	11	0.15	1.12	0.27	0.32	0.99	0.30	0.53	0.39
	2n	0.49	0.47	0.27	0.37	-	-	0.40	0.39
	6n	0.05	0.10	0.08	0.06	-	0.14	0.09	0.39
SHRUBS	3	0.06	0.16	0.05	0.10	0.07	0.05	0.08	0.32
	4	0.24	1.00	1.68	0.29	-	-	0.80	0.32
	5	0.20	0.05	0.12	0.06	0.05	0.17	0.11	0.32
	13	-	-	-	-	0.14	0.43	0.28	0.32
	16	0.17	-	-	-	-	-	0.17	0.32
	20	-	-	-	-	-	0.10	0.10	0.32
	21	0.71	-	-	-	-	-	0.71	0.32
LICHENS	7	-	-	-	-	0.53	0.72	0.62	0.67
	8	0.95	1.09	0.93	1.01	-	-	1.00	0.67
	10	-	-	-	-	0.32	0.45	0.38	0.67
SOIL		24.33	40.67	13.00	11.33	12.67	9.33	18.56	18.56
LOCALITY MEAN		0.50	0.76	0.58	0.47	0.40	0.33		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

MAGNES: Grand mean= 874.23 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	757.00	887.50	-	-	716.33	-	786.94	828.56
	11	918.33	687.67	839.00	859.67	732.67	789.33	804.44	828.56
	2n	873.67	962.00	770.00	938.00	-	-	885.92	828.56
	6n	816.00	1064.00	778.00	849.67	-	704.83	842.50	828.56
SHRUBS	3	1392.00	1315.00	1044.83	1200.67	1118.67	923.33	1165.75	1161.10
	4	889.33	867.00	974.67	971.67	-	-	925.67	1161.10
	5	1166.33	1195.33	1220.00	1228.33	1282.67	1011.17	1183.97	1161.10
	13	-	-	-	-	1821.67	1557.67	1689.67	1161.10
	16	1189.00	-	-	-	-	-	1189.00	1161.10
	20	-	-	-	-	-	1177.33	1177.33	1161.10
	21	796.33	-	-	-	-	-	796.33	1161.10
LICHENS	7	-	-	-	-	239.67	236.00	237.83	216.25
	8	235.00	261.67	254.00	259.00	-	-	252.42	216.25
	10	-	-	-	-	166.67	150.33	158.50	216.25
SOIL		2833.33	1566.67	506.67	1080.00	1600.00	1386.67	1495.56	1495.56
LOCALITY MEAN		725.94	750.93	709.83	758.33	778.44	702.54		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

MANGAN: Grand mean= 431.683 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	354.500	475.000	-	-	438.667	-	422.722	361.026
	11	282.167	294.000	98.300	113.267	176.000	180.467	190.700	361.026
	2n	435.667	565.333	170.067	308.667	-	-	369.933	361.026
	6n	672.000	608.000	509.333	450.667	-	756.333	599.267	361.026
SHRUBS	3	609.000	939.000	527.333	479.667	799.333	560.667	652.500	426.333
	4	219.233	218.000	70.533	60.033	-	-	141.950	426.333
	5	1376.333	1334.333	1148.000	1035.000	1196.000	1044.167	1188.972	426.333
	13	-	-	-	-	335.000	342.333	338.667	426.333
	16	39.440	-	-	-	-	-	39.440	426.333
	20	-	-	-	-	-	451.333	451.333	426.333
	21	171.467	-	-	-	-	-	171.467	426.333
LICHENS	7	-	-	-	-	68.333	97.233	82.783	59.253
	8	27.333	63.300	47.033	40.233	-	-	44.475	59.253
	10	-	-	-	-	51.000	50.000	50.500	59.253
SOIL		131.000	403.667	37.667	47.667	87.333	55.000	127.056	127.056
LOCALITY MEAN		301.051	451.100	296.074	285.333	381.259	380.547		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

MOLYB: Grand mean= 0.39 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	0.29	0.38	-	-	0.19	-	0.29	0.34
	11	0.34	0.33	0.26	0.25	0.37	0.20	0.29	0.34
	2n	0.51	0.58	0.37	0.41	-	-	0.47	0.34
	6n	0.24	0.19	0.29	0.23	-	0.25	0.24	0.34
SHRUBS	3	0.32	0.25	0.35	0.25	0.20	0.18	0.26	0.53
	4	1.31	0.39	2.75	0.37	-	-	1.20	0.53
	5	0.51	0.33	0.69	0.35	0.36	0.42	0.44	0.53
	13	-	-	-	-	0.42	0.30	0.36	0.53
	16	0.32	-	-	-	-	-	0.32	0.53
	20	-	-	-	-	-	0.38	0.38	0.53
	21	0.76	-	-	-	-	-	0.76	0.53
LICHENS	7	-	-	-	-	0.11	0.13	0.12	0.14
	8	0.16	0.15	0.23	0.20	-	-	0.18	0.14
	10	-	-	-	-	0.12	0.13	0.12	0.14
SOIL		10.33	15.00	3.00	5.00	5.00	3.00	6.89	6.89
LOCALITY MEAN		0.39	0.29	0.60	0.27	0.24	0.23		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

NICKEL: Grand mean= 1.229 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	0.902	3.605	-	-	0.279	-	1.595	1.474
	11	1.042	2.457	0.503	2.440	0.643	0.897	1.330	1.474
	2n	0.710	5.073	0.526	1.707	-	-	2.004	1.474
	6n	0.192	3.705	0.233	1.238	-	0.468	1.167	1.474
SHRUBS	3	1.044	1.832	0.921	1.861	0.690	0.819	1.195	1.360
	4	1.370	5.693	1.620	3.033	-	-	2.929	1.360
	5	0.585	0.960	0.309	0.707	0.234	0.396	0.532	1.360
	13	-	-	-	-	0.922	2.029	1.475	1.360
	16	0.464	-	-	-	-	-	0.464	1.360
	20	-	-	-	-	-	1.881	1.881	1.360
	21	1.041	-	-	-	-	-	1.041	1.360
LICHENS	7	-	-	-	-	0.288	0.269	0.278	0.307
	8	0.404	0.668	0.309	0.377	-	-	0.440	0.307
	10	-	-	-	-	0.196	0.211	0.204	0.307
SOIL		16.000	24.000	23.000	17.333	8.000	10.000	16.389	16.389
LOCALITY MEAN		0.704	2.407	0.560	1.346	0.439	0.735		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

PHOSPHOR: Grand mean= 841.1 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	813.5	842.0	-	-	644.7	-	766.7	900.4
	11	833.3	709.0	775.7	683.0	763.3	956.5	786.8	900.4
	2n	1157.3	1057.3	874.0	1132.3	-	-	1055.3	900.4
	6n	648.0	1102.0	960.0	922.0	-	941.7	914.7	900.4
SHRUBS	3	1102.0	996.0	1143.8	1191.3	1095.7	983.0	1085.3	960.1
	4	866.7	817.7	1125.3	950.7	-	-	940.1	960.1
	5	896.3	864.7	877.0	925.3	788.7	844.0	866.0	960.1
	13	-	-	-	-	846.7	903.0	874.8	960.1
	16	783.0	-	-	-	-	-	783.0	960.1
	20	-	-	-	-	-	1365.3	1365.3	960.1
	21	806.0	-	-	-	-	-	806.0	960.1
LICHENS	7	-	-	-	-	508.3	570.7	539.5	444.1
	8	375.7	429.7	463.0	485.3	-	-	438.4	444.1
	10	-	-	-	-	346.0	363.0	354.5	444.1
SOIL		273.3	326.7	86.0	203.3	226.7	286.7	233.8	233.8
LOCALITY MEAN		727.6	740.3	793.9	806.7	680.5	813.2		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

POTASS: Grand mean= 1913.9 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	1894.0	2181.0	-	-	1769.3	-	1948.1	1486.3
	11	1025.3	1361.7	1098.3	980.0	1290.3	1400.7	1192.7	1486.3
	2n	1283.7	1535.7	1120.0	1463.3	-	-	1350.7	1486.3
	6n	2352.0	1349.0	1808.7	1999.3	-	1966.2	1895.0	1486.3
SHRUBS	3	2697.0	2596.3	2416.3	2826.3	1749.7	1599.3	2314.2	2574.6
	4	2357.3	2546.7	3316.7	2683.3	-	-	2726.0	2574.6
	5	2288.7	2051.3	2377.3	2365.0	1924.0	2735.8	2290.4	2574.6
	13	-	-	-	-	2385.0	2705.7	2545.3	2574.6
	16	2204.0	-	-	-	-	-	2204.0	2574.6
	20	-	-	-	-	-	3083.3	3083.3	2574.6
	21	2858.7	-	-	-	-	-	2858.7	2574.6
LICHENS	7	-	-	-	-	1626.7	1440.7	1533.7	1290.5
	8	1108.7	1362.7	1300.0	1360.0	-	-	1282.8	1290.5
	10	-	-	-	-	1073.3	1036.7	1055.0	1290.5
SOIL		583.3	496.7	466.7	523.3	1113.3	663.3	641.1	641.1
LOCALITY MEAN		1680.6	1787.0	1781.9	1821.9	1633.1	1817.7		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

SILVER: Grand mean= 0.115 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	0.104	0.159	-	-	0.146	-	0.136	0.102
	11	0.066	0.107	0.027	0.042	0.070	0.033	0.058	0.102
	2n	0.084	0.159	0.043	0.053	-	-	0.085	0.102
	6n	0.168	0.152	0.165	0.123	-	0.274	0.176	0.102
SHRUBS	3	0.116	0.206	0.124	0.101	0.211	0.101	0.143	0.107
	4	0.087	0.103	0.087	0.102	-	-	0.095	0.107
	5	0.323	0.295	0.254	0.221	0.234	0.258	0.264	0.107
	13	-	-	-	-	0.118	0.089	0.104	0.107
	16	0.015	-	-	-	-	-	0.015	0.107
	20	-	-	-	-	-	0.089	0.089	0.107
	21	0.042	-	-	-	-	-	0.042	0.107
LICHENS	7	-	-	-	-	0.033	0.029	0.031	0.030
	8	0.026	0.022	0.043	0.042	-	-	0.033	0.030
	10	-	-	-	-	0.023	0.030	0.027	0.030
SOIL		0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
LOCALITY MEAN		0.078	0.122	0.092	0.085	0.108	0.106		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

SODIUM: Grand mean= 17.4 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	8.1	7.9	-	-	8.9	-	8.3	10.5
	11	11.8	29.6	8.2	10.6	6.9	11.1	13.0	10.5
	2n	8.7	5.6	4.2	4.5	-	-	5.7	10.5
	6n	16.8	9.7	15.1	18.7	-	14.0	14.9	10.5
SHRUBS	3	29.0	11.1	12.1	60.6	7.3	8.8	21.5	14.9
	4	19.3	15.3	9.7	14.6	-	-	14.7	14.9
	5	21.8	11.9	8.5	9.1	7.2	11.6	11.7	14.9
	13	-	-	-	-	10.3	12.6	11.4	14.9
	16	22.6	-	-	-	-	-	22.6	14.9
	20	-	-	-	-	-	12.1	12.1	14.9
	21	10.1	-	-	-	-	-	10.1	14.9
LICHENS	7	-	-	-	-	21.3	35.5	28.4	32.3
	8	79.3	63.1	23.9	29.9	-	-	49.0	32.3
	10	-	-	-	-	15.1	23.9	19.5	32.3
SOIL		193.3	146.7	296.7	283.3	220.0	280.0	236.7	236.7
LOCALITY MEAN		36.8	30.1	14.4	23.1	11.4	17.8		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

TITANIUM: Grand mean= 1.379 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	0.830	0.720	-	-	0.157	-	0.569	0.677
	11	0.900	1.236	0.698	0.709	0.306	0.892	0.790	0.677
	2n	0.851	1.192	0.739	0.799	-	-	0.895	0.677
	6n	0.528	0.038	0.243	0.124	-	0.331	0.253	0.677
SHRUBS	3	2.610	0.980	0.992	0.758	0.306	0.730	1.063	0.943
	4	0.879	0.761	0.271	0.303	-	-	0.554	0.943
	5	1.545	0.809	0.707	0.671	0.312	0.588	0.772	0.943
	13	-	-	-	-	0.372	1.487	0.930	0.943
	16	2.030	-	-	-	-	-	2.030	0.943
	20	-	-	-	-	-	0.436	0.436	0.943
	21	0.821	-	-	-	-	-	0.821	0.943
LICHENS	7	-	-	-	-	1.143	4.140	2.641	3.819
	8	9.370	7.943	4.050	3.167	-	-	6.133	3.819
	10	-	-	-	-	2.623	2.740	2.682	3.819
SOIL		470.000	573.333	360.000	390.000	543.333	620.000	492.778	492.778
LOCALITY MEAN		3.924	3.256	1.756	1.429	0.815	1.620		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

VANADIUM: Grand mean= 0.56 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	0.45	0.63	-	-	0.36	-	0.48	0.44
	11	0.45	0.42	0.33	0.35	0.36	0.34	0.38	0.44
	2n	0.41	0.65	0.42	0.43	-	-	0.48	0.44
	6n	0.48	0.42	0.49	0.45	-	0.46	0.46	0.44
SHRUBS	3	0.75	0.64	0.59	0.56	0.54	0.50	0.60	0.60
	4	0.57	0.41	0.63	0.52	-	-	0.53	0.60
	5	0.82	0.60	0.64	0.58	0.63	0.70	0.66	0.60
	13	-	-	-	-	0.72	0.72	0.72	0.60
	16	0.64	-	-	-	-	-	0.64	0.60
	20	-	-	-	-	-	0.57	0.57	0.60
	21	0.51	-	-	-	-	-	0.51	0.60
LICHENS	7	-	-	-	-	0.43	0.63	0.53	0.61
	8	1.03	1.06	0.71	0.67	-	-	0.87	0.61
	10	-	-	-	-	0.40	0.48	0.44	0.61
SOIL		26.00	43.67	11.33	14.67	16.00	15.33	21.17	21.17
LOCALITY MEAN		0.71	0.72	0.58	0.54	0.47	0.53		

SUMMARY TABLE OF WEIGHTED MEANS BY LOCALITY AND SPECIES.
GRAND AND LOCALITY MEANS EXCLUDE SOIL DATA.

ZINC: Grand mean= 40.034 ug/gm dry wt

		N. SASK./N.W.T. LOCALITIES							
		URANIUM CITY	EAGLE LAKE	TAZIN RIVER	ENA LAKE	MCINNES LAKE	DUNVEGAN LAKE	SPECIES MEAN	GROUP MEAN
		ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt	ug/gm dry wt		
GROUP	SPECIES								
TREES	6	36.600	41.700	-	-	43.233	-	40.511	71.171
	11	130.000	109.767	83.100	186.533	130.000	149.600	131.500	71.171
	2n	44.000	41.833	28.833	43.067	-	-	39.433	71.171
	6n	40.800	22.800	46.267	40.733	-	51.850	40.490	71.171
SHRUBS	3	19.140	21.283	19.237	20.013	19.067	18.503	19.541	30.272
	4	21.090	46.667	23.753	49.367	-	-	35.219	30.272
	5	15.037	14.253	18.613	21.333	18.720	22.607	18.427	30.272
	13	-	-	-	-	13.867	12.460	13.163	30.272
	16	50.750	-	-	-	-	-	50.750	30.272
	20	-	-	-	-	-	57.833	57.833	30.272
	21	16.972	-	-	-	-	-	16.972	30.272
LICHENS	7	-	-	-	-	12.267	14.100	13.183	11.225
	8	9.533	14.367	10.067	11.933	-	-	11.475	11.225
	10	-	-	-	-	9.700	8.333	9.017	11.225
SOIL		49.667	48.000	22.333	22.000	14.667	14.333	28.500	28.500
LOCALITY MEAN		34.933	34.700	27.778	44.094	38.273	46.598		

Appendix 8.5 Principal components analysis of vascular plant samples.

Correlations of elements with first six components (eigenvalues > 1) rotated to simple structure.

Variables	Rotated component loadings						Communalities
	1	2	3	4	5	6	
PB^{210}	0.305	0.651	0.146	0.030	-.235	0.378	0.737
RA^{226}	-.053	0.665	-.106	-.381	0.155	0.092	0.634
URANIUM	0.149	0.064	-.097	-.020	-.135	0.796	0.688
BORON	0.796	0.093	-.024	-.110	0.213	-.113	0.714
PHOSPHORUS	0.181	0.033	-.261	0.692	-.181	-.208	0.657
SILVER	0.779	-.046	-.140	-.336	-.177	-.058	0.775
ALUMINUM	0.629	-.203	-.066	0.158	-.392	0.377	0.761
BERYLLIUM	0.109	0.236	-.298	0.732	0.142	0.313	0.810
CALCIUM	0.356	-.260	.624	-.051	0.158	0.192	0.648
CADMIUM	-.101	0.036	0.723	0.013	0.038	-.045	0.538
COBALT	-.216	0.709	0.193	0.182	0.324	0.122	0.739
CHROMIUM	0.764	.182	-.044	0.206	-.071	0.370	0.804
COPPER	0.299	0.712	-.017	0.143	0.030	-.256	0.684
IRON	0.764	0.253	0.013	0.365	-.046	0.328	0.890
POTASSIUM	-.129	-.154	-.732	0.260	0.068	0.092	0.657
MAGNESIUM	0.523	0.215	-.449	0.252	-.326	-.113	0.704
MANGANESE	0.695	-.196	-.188	-.392	-.331	-.103	0.831
SODIUM	0.608	0.155	-.175	0.078	-.086	-.035	0.440
NICKEL	-.035	0.728	0.184	0.408	0.161	-.058	0.761
LEAD	-.207	0.420	0.123	-.112	0.696	0.080	0.737
TITANIUM	0.771	0.133	0.042	0.249	0.094	0.079	0.691
VANADIUM	0.863	-.089	-.222	0.123	-.085	0.169	0.852
ZINC	-.205	-.037	0.816	-.134	0.211	0.118	0.785
BARIUM	0.057	0.055	-.023	0.057	0.869	-.273	0.840
EIGENVALUE[1]	6.867	3.714	2.453	1.778	1.306	1.260	17.378
EIGENVALUE[2]	5.810	3.023	2.745	2.111	2.074	1.614	17.378
PROPORTION[3]	0.242	0.126	0.114	0.088	0.086	0.067	0.724
CUMULATIVE[4]	0.242	0.368	0.482	0.570	0.657	0.724	

[1]Eigenvalue prior to rotation
[2]Eigenvalue after rotation
[3]Proportion of variance extracted
[4]Cumulative variance extracted

Appendix 8.6. Principal components analysis of non-vascular plant samples. Correlations of elements with first six components (eigenvalues > 1) rotated to simple structure.

Variable	Rotated component loadings						Communalities
	1	2	3	4	5	6	
PB^{210}	0.426	0.103	0.075	0.047	0.772	0.134	0.814
RA^{226}	0.189	-.036	0.925	0.029	0.078	-.105	0.911
URANIUM	0.115	0.166	0.596	0.218	0.585	-.247	0.848
BORON	0.044	0.760	-.012	0.109	0.080	-.002	0.597
PHOSPHORUS	-.070	0.929	0.054	0.075	-.106	-.052	0.890
SILVER	-.234	0.099	0.880	-.127	-.057	0.170	0.887
ALUMINUM	0.914	-.031	0.061	0.152	0.185	0.055	0.900
BERYLL	0.884	-.136	-.105	0.316	0.079	0.029	0.917
CALCIUM	0.052	0.892	-.024	-.057	0.156	0.281	0.906
CADMIUM	0.320	0.318	-.331	0.763	0.090	-.029	0.904
COBALT	0.847	0.108	-.056	0.173	0.152	0.232	0.838
CHROMIUM	0.602	0.016	-.154	0.195	0.461	-.342	0.753
COPPER	0.056	0.825	-.009	0.404	0.209	-.023	0.890
IRON	0.921	0.003	0.041	0.238	0.058	0.107	0.923
POTASSIUM	-.103	0.945	0.081	-.003	0.162	0.098	0.946
MAGNESIUM	0.020	0.903	0.089	-.070	0.116	0.283	0.923
MANGANESE	-.049	0.807	0.094	-.233	-.284	-.026	0.798
SODIUM	0.703	0.337	-.099	-.150	0.200	0.387	0.829
NICKEL	0.736	0.121	-.027	-.236	0.297	-.445	0.898
LEAD	0.551	-.052	0.231	0.674	0.139	0.119	0.847
TITANIUM	0.918	-.229	-.070	0.147	0.088	0.074	0.935
VANADIUM	0.855	0.206	0.202	-.132	-.181	-.231	0.918
ZINC	0.242	0.640	-.271	0.315	-.171	-.136	0.687
BARIUM	0.294	0.427	-.027	0.049	0.012	0.769	0.863
EIGENVALUE[1]	8.162	6.072	2.496	1.545	1.318	1.032	20.626
EIGENVALUE[2]	7.016	6.253	2.356	1.812	1.656	1.506	20.626
PROPORTION[3]	0.292	0.261	0.098	0.075	0.069	0.063	0.859
CUMULATIVE[4]	0.292	0.553	0.651	0.726	0.795	0.859	

[1]Eigenvalue prior to rotation
[2]Eigenvalue after rotation
[3]Proportion of variance extracted
[4]Cumulative variance extracted

Appendix 8.7. Canonical correlation analysis comparing radionuclide and stable element concentrations in vascular plant samples.

Canonical variates	Canonical correlation	Eigenvalue	Proportion of variance	Cumulative explained variance	Probability
1	0.824	2.110	0.645	0.645	0.001
2	0.696	0.940	0.287	0.932	0.002
3	0.428	0.224	0.068	1.000	0.631

Intraset canonical structure

Radionuclides	Canonical variates V1	V2	Communalities
Pb^{210}	0.995	-.052	0.993
Ra^{226}	0.308	0.792	0.722
Uranium	0.408	-.571	0.492
Variance	0.417	0.319	0.736
Redundancy	0.283	0.154	0.437

Stable elements	Canonical variates W1	W2	Communalities
Boron	0.260	0.088	0.075
Phosphorus	-.020	-.195	0.038
Silver	0.231	-.111	0.066
Aluminum	0.207	-.440	0.236
Beryllium	0.280	-.161	0.104
Calcium	-.063	-.250	0.066
Cadmium	0.094	0.039	0.010
Cobalt	0.425	0.596	0.536
Chromium	0.307	-.538	0.384
Copper	0.614	0.291	0.462
Iron	0.654	-.312	0.525
Potassium	-.218	-.218	0.095
Magnesium	0.359	-.172	0.158
Manganese	0.064	-.130	0.021
Sodium	0.293	-.045	0.088
Nickel	0.480	0.468	0.449
Lead	0.156	0.446	0.223
Titanium	0.344	-.099	0.128
Vanadium	0.318	-.393	0.256
Zinc	0.052	0.092	0.011
Barium	-.233	0.322	0.158
Variance	0.101	0.093	0.194
Redundancy	0.070	0.045	0.115

Appendix 8.8 Canonical correlation analysis comparing radionuclide and stable element concentrations in non-vascular plant samples.

Canonical variates	Canonical correlation	Eigenvalue	Proportion of variance	Cumulative explained variance	Probability
1	0.948	8.969	0.604	0.604	0.001
2	0.905	4.537	0.306	0.910	0.018
3	0.756	1.333	0.090	1.000	0.360

Intraset canonical structure

Radionuclides	Canonical variates V1	V2	Communalities
Pb^{210}	0.749	0.511	0.822
Ra^{226}	0.782	-.523	0.885
Uranium	0.750	0.311	0.659
Variance	0.578	0.210	0.789
Redundancy	0.520	0.172	0.692

Stable elements	Canonical variates W1	W2	Communalities
Boron	0.098	0.197	0.048
Phosphorus	-.040	0.168	0.030
Silver	0.493	-.608	0.613
Aluminum	0.481	0.237	0.287
Beryllium	0.329	0.170	0.137
Calcium	0.129	0.320	0.119
Cadmium	-.008	0.511	0.261
Cobalt	0.452	0.200	0.244
Chromium	0.342	0.401	0.278
Copper	0.196	0.407	0.204
Iron	0.404	0.124	0.179
Potassium	0.146	0.273	0.096
Magnesium	0.153	0.286	0.105
Manganese	-.046	-.047	0.004
Sodium	0.369	0.155	0.160
Nickel	0.458	0.175	0.240
Lead	0.494	0.169	0.273
Titanium	0.364	0.106	0.144
Vanadium	0.389	-.233	0.206
Zinc	-.051	0.202	0.043
Barium	0.091	0.053	0.011
Variance	0.098	0.075	0.173
Redundancy	0.088	0.062	0.150

Appendix 8.9. Canonical variates analysis by localities.

Canonical variate	Canonical correlation	Eigenvalue	Proportion of variance	Cumulative variance	Probability
1	0.944	8.211	0.471	0.471	.0001
2	0.867	3.678	0.211	0.682	.0001
3	0.779	1.549	0.089	0.770	.0367

Variables	Intraset canonical structure				Interset
	CAN 1	CAN 2	CAN 3	Communalities	Communalities
PB^{210}	0.035	0.105	0.006	0.012	0.552
RA^{226}	-.166	0.064	-.019	0.032	0.507
URANIUM	0.057	0.332	-.343	0.122	0.776
BORON	0.037	-.138	-.073	0.026	0.645
PHOSPHORUS	0.044	0.013	-.013	0.002	0.215
SILVER	0.079	-.195	-.084	0.051	0.875
ALUMINUM	0.203	-.034	0.060	0.046	0.818
BERYLLIUM	0.095	0.062	0.165	0.040	0.643
CALCIUM	0.078	-.092	0.006	0.015	0.620
CADMIUM	-.033	0.006	0.021	0.002	0.157
COBALT	-.020	0.073	0.073	0.011	0.213
CHROMIUM	0.272	0.029	0.091	0.083	0.913
COPPER	-.027	0.005	0.005	0.001	0.123
IRON	0.116	0.023	0.140	0.033	0.666
POTASSIUM	0.055	0.073	0.007	0.008	0.559
MAGNESIUM	0.016	-.031	0.009	0.001	0.166
MANGANESE	0.067	-.153	-.090	0.036	0.766
SODIUM	0.095	0.026	0.080	0.016	0.527
NICKEL	0.015	0.081	0.041	0.008	0.132
LEAD	-.039	0.034	0.067	0.007	0.242
TITANIUM	0.090	-.004	0.158	0.033	0.538
VANADIUM	0.234	-.217	0.022	0.102	0.863
ZINC	-.037	-.076	-.045	0.009	0.361
BARIUM	-.083	-.128	0.111	0.036	0.568
VARIANCE	0.011	0.013	0.011	0.035	0.518
REDUNDANCY	0.285	0.179	0.055	0.518	

Appendix 8.10. Canonical variates analysis by species.

Canonical variate	Canonical correlation	Eigenvalue	Proportion of variance	Cumulative variance	Probability
1	0.996	134.135	0.708	0.708	0.0001
2	0.976	19.847	0.105	0.813	0.0001
3	0.970	15.785	0.083	0.896	0.0001
4	0.946	8.524	0.045	0.941	0.0001

Variables	Intraset canonical structure					Interset
	CAN 1	CAN 2	CAN 3	CAN 4	Communalities	Communalities
PB^{210}	-.234	0.128	0.221	0.288	0.203	0.961
RA^{226}	0.024	0.106	-.000	0.153	0.035	0.770
URANIUM	-.049	0.015	0.052	0.045	0.007	0.961
BORON	0.247	0.006	-.099	0.065	0.075	0.979
PHOSPHORUS	0.159	0.042	-.057	-.130	0.047	0.921
SILVER	0.099	-.047	0.139	0.110	0.043	0.866
ALUMINUM	-.078	-.143	0.356	0.257	0.219	0.870
BERYLLIUM	-.105	0.070	0.112	0.036	0.001	0.931
CALCIUM	0.225	-.035	0.026	-.134	0.071	0.971
CADMIUM	-.071	-.048	-.311	0.341	0.220	0.960
COBALT	-.030	0.187	-.156	-.025	0.061	0.688
CHROMIUM	-.043	0.005	0.156	0.116	0.040	0.720
COPPER	0.407	0.473	-.206	0.359	0.560	0.993
IRON	-.154	0.107	0.242	0.253	0.158	0.913
POTASSIUM	0.104	0.031	0.035	-.260	0.080	0.890
MAGNESIUM	0.528	0.002	-.156	-.113	0.316	0.992
MANGANESE	0.257	-.224	0.170	0.065	0.149	0.966
SODIUM	-.101	0.022	0.217	0.140	0.077	0.899
NICKEL	0.051	0.168	-.099	0.032	0.042	0.729
LEAD	-.157	0.081	0.053	0.074	0.040	0.952
TITANIUM	-.150	0.077	0.233	0.272	0.156	0.963
VANADIUM	-.028	0.015	0.192	0.096	0.047	0.736
ZINC	0.038	-.182	-.586	0.220	0.426	0.972
BARIUM	0.068	0.065	-.104	-.101	0.030	0.915
VARIANCE	0.035	0.019	0.043	0.037	0.134	0.896
REDUNDANCY	0.557	0.079	0.180	0.079	0.896	